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Prof. Perry's Indicator. IN our cable dispatch this week will be found a brief notice of the new steam engine indicator brought out by Prof. John Perry. The principle of producing continuous luminous figures of which the form may be studied is of course not new, as it has been employed on a small scale in acoustical investigations for a long time, but its application to the steam indicator is very neat and convenient. It ought to prove specially handy in that part of the work of the indicator which relates to the adjustment of valves and similar problems, for a continuously visible diagram is for this use a decided improvement on the separate records now taken. Aside from this advantage, such an apparatus ought to be capable of a construction that would give very slight inertia to the parts, and consequently would offer a diagram free from some of the irregularities that are only too apparent in ordinary instruments.

The Incandescent Lamp Suit. ON another page we devote some space to a general discussion of the great incandescent lamp suit that is in progress as we go to press. It is the result of some years of incipient and growing litigation, and involves no less a stake than the monopoly of incandescent lamp manufacture. If the Edison fundamental patent should be sustained, the other companies that have been in the habit of making incandescent lamps would be seriously embarrassed in that department of their work. The English Edison patent has had a varied career, but not much can be judged from this as to the probable result here, where, to a certain extent, questions of sentiment as well as law are involved. Even from a purely scientific standpoint the complication of facts concerned is immensely intricate, and the interpretations to be put on certain important claims, taking into consideration the collateral circumstances, are anything but plain. It is fortunate, indeed, that such a case is not to be tried before a jury; and in spite of Judge Wallace's high reputation one instinctively wishes that such a cause might have fallen under the jurisdiction of a man eminent in science as well as in law.

Democratic Electricity. DID it ever occur to you that there is something essentially undemocratic in the opposition to electric roads that has made itself felt so viciously in and about many cities? You never hear the vast crowd of workingmen, who appreciate to the fullest the blessing of being able to secure a home in the suburbs, make the complaints that are promulgated by the daily press. They come very largely from the class of people who own their own carriages and do not (unless compelled by necessity) use the electric cars at all. Not that they feel particularly aggrieved that their poorer neighbors are not compelled to walk, but there is some inconvenience in driving through streets where there is a continuous street car service of whatever kind; and, furthermore, the results of rapid transit on the distribution of population in a city are such as do not altogether please the magnates who enthusiastically endorse the sentiments of the late W. H. Vanderbilt concerning the public. The electric car makes it possible for workingmen and others of comparatively small means to get out of the crowded city beyond the present limits of the aristocratic suburbs, and tends to form a belt of small homes surrounding our present cities. Why these should be distasteful to those who occupy the present suburbs, it is not altogether easy to see, but that such is the case is only too evident from the essentially vigorous protests that are raised.

A Continental Central Station. IN this issue is given a full account of one of the successful Continental electric lighting stations. It is especially interesting as exemplifying a type of construction not generally employed in this country. The use of very large direct-coupled dynamos has not found its way into American practice to any extent, though just now there is something of a tendency in this direction. The machines used in the Berlin central station have performed admirably, and ought to encourage American engineers to do something of the sort in our own metropolitan lighting plants. Of course the old Jumbo dynamo was one of the earliest specimens of the direct-coupled type, but it was irremediably inefficient, and it was not until the introduction of the large multipolar machines that the direct-connected dynamo became practicable. Even now it ought to be well noted by electrical engineers that the size and distribution of the load in a given central station should determine the maximum size of the dynamo that is to be used therein. So far as power is concerned, that plant is most economical which runs regularly at its full capacity. If the total load is large enough to permit several 500 h. p. dynamos to be fully loaded, such electrical giants can be employed with great advantage. On the other hand, if the load is of a character that would permit, for example, the continuous use of only a single pair of these machines, it becomes a grave question whether they might not be replaced with advantage by four or six smaller machines, for the obvious reason that it would be an unpleasant thing for a station to be completely paralyzed by a small fault of a single engine; so, in spite of the economy and efficiency of these huge machines, they should be employed with a clear understanding of the fact that there is such a thing as putting too many eggs in one basket.

The Electric Dirigible Torpedo. THE recent trials of the Sims-Edison torpedo in the port of Havre, give promise of a practical utility for defense that ought to furnish some consolation to alarmists. In a recent issue we gave a description of the use of this formidable weapon of war for defending channels such as we find about New York. The dirigible torpedo is a vast improvement over the Whitehead and other automobile forms; for it must be remembered that the action of these is very erratic, as has been shown most conclusively by the practical experiments tried in the present Chilian insurrection. Indeed, there is every reason why it should be so, for they are discharged from a directing tube scarcely longer than the torpedo itself at an initial velocity enormously lower than that of a cannon ball or even a pistol shot. A ball fired from a short-barreled pistol, even when the latter is screwed in a vise, is by no means certain of going even reasonably close to the point aimed at; and when a torpedo is sent not through air, but through water, and at a very much lower speed, it is no particular wonder that hits are few. With a dirigible torpedo, however, the conditions are quite different, for the missile is not dependent on its initial direction, and can be deliberately steered to the mark. The advantage of this is obvious, and it is to be hoped that our naval and military authorities will see the point, and take care to provide themselves even more liberally than has ever yet been planned with the class of weapon that has such an evident field of usefulness.

Official Rapid Transit. AFTER many weeks of deliberations, worried by politicians and harassed by inventors, the Rapid Transit Commission has at last made up its composite mind to a tentative report. It is not altogether satisfactory in that it does not give any very clear idea of the working plans that would be favored by the engineers of the Commission. Nevertheless, in general, the proposed rapid transit scheme is commendable, and when, some weeks from now, a further report from the engineers is received, it may be that the prospect of real rapid transit will not seem quite so much like a mirage as at present. The report itself is, in its main provisions, eminently sensible. It recognizes in the first place the necessity for express trains at high speed in addition to a local service; a system so devised as to be susceptible of expansion; so located that it shall, as far as possible, coincide with the natural line of traffic; and so executed that it shall obstruct the streets in the least possible degree. As best meeting these requirements, from the numerous suggestions offered to the board, it has chosen the underground system as the most practicable. Specifically, the thing recommended is an underground four-track road under Broadway from a point near South Ferry to Fifty-ninth street, thence under the Boulevard to a point at or near 169th street (perhaps with a section of viaduct at Manhattan street); from 169th street, under Eleventh avenue, to Spuyten Duyvil Creek, which it is to cross on a viaduct, and thence by tunnel or viaduct, as proves most convenient, to the city limits. The plan of construction recommended is a four-track tunnel, either double-decked or with all the tracks on a level, as may prove most feasible. This arrangement is to be followed up as far as Forty-second street. North of this point four parallel tracks on the same level are specifically recommended. As to motive power, electricity is emphatically preferred by the board, for their former recommendation calls for this or some other power not requiring combustion within the tunnel. The actual report is far better than the mongrel suggestions unofficially made by a commissioner for a combined structure: underground to please one faction; viaduct to suit the desire for acquisition of the second party; and elevated to soothe the ruffled feelings of Jay Gould and his philanthropic associates. Now, looking at the matter from a practical standpoint, one has to face the fact that a choice of a system lay between underground and elevated lines. A viaduct and similar schemes were stamped with impracticability at the very outset by the enormous cost. One must realize that the traffic even in this metropolis is by no means infinite, and that whatever system of rapid transit is employed must divide patronage and proceeds with the present elevated system. Something like half a million passengers per day are now carried on the agglomerated overhead lines. Their capacity could be somewhat but not largely increased under the present circumstances. It is beyond the regions of possibility that all this traffic could be withdrawn by an underground road, or that, considering the fact that much of the traffic is local, any very large fraction of it could be certainly counted upon. This condition of affairs limits the amount of capital that can be profitably put into any new rapid transit system. Knowing what we do of the number of passengers now carried, and that running expenses are likely to be at least 50 per cent. of the gross receipts, it becomes evident by a few moments' calculation that any plan demanding a hundred million dollars would not prove a remunerative investment, at least within the lifetime of the present generation. If there should be any doubt on this point it must be remembered, in addition, that any serious inroads on the profits of the elevated railroads would be immediately met by a cut in rates with which an underground or viaduct system could not keep pace. A tunnel, and a comparatively cheap tunnel, such as the commissioners have recommended, has from the first seemed to be the only practicable method of increasing the facilities for transit through the length of Manhattan Island. Granted a tunnel, electric motive power follows as a logical consequence, and of its complete success there is not even a plausible reason for doubt in face of the success of the City & South London Railway. In regard to the construction favored by the board, few conclusions can be drawn, except that the suggestions made look toward the Reno double-decked tunnel recently described in THE ELECTRICAL WORLD, at least for the lower portion of the city. No other plan possessed of the same characteristics of compact double-decked form was presented to the Commission. The Greathead plan used in London has had very many friends, but the method loses its useful characteristics in rocky earth. The engineers of the board are known to be working up the detailed plans—perhaps on the line just mentioned, or possibly modified according to the ideas of the engineers themselves. In a few weeks more we may hear something definite and authoritative. At present we can only express the utmost satisfaction that a tunnel of reasonable cost, and electric motive power, have been emphatically recommended.

Latest Foreign Electrical News.

(By cable from our regular correspondent.)

London, June 1, 1891.—At a meeting of the Physical Society last week, Prof. Perry exhibited an interesting and novel form of steam-engine indicator, consisting of an illuminated mirror, subject simultaneously to two rotary motions at right angles to each other. These motions are produced by the movements of the pistons of the engine and indicator, and variations in pressure are traced continuously by the mirror, forming a diagram always visible to the eye.

A curious accident happened in Paris last week. An employé of the London and Paris telephone line received a severe shock from the receiver of the instrument. Of course cables like that employed have very considerable electrostatic capacity, and it seems altogether probable that the shock came from a static discharge to the earth from the line.

Speaking of submarine affairs, a deputation of the Associated Chambers of Commerce has taken up the question of telegraphic communication between isolated lighthouses and the shore, and has strongly urged action in this direction by the Board of Trade.

The Incandescent Lamp Patent Suit.

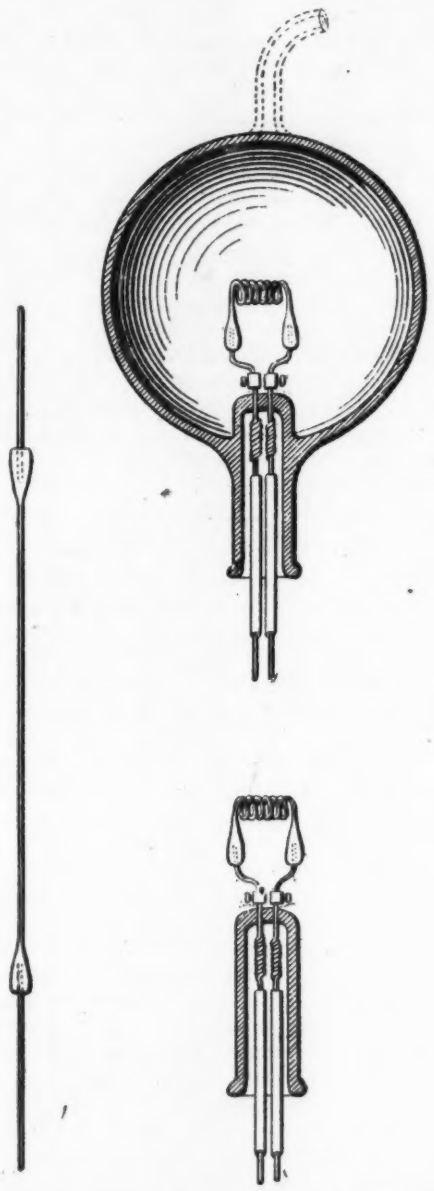
As we go to press there is on trial before the Circuit Court in this city what may perhaps be characterized as the most important patent suit instituted in the history of our country. It is the suit for infringement brought by the Edison Electric Light Company against the United States Electric Light Company, and involves the entire incandescent lamp industry of the country. It is unique in importance, not only on account of the great value of the invention itself, but by reason of the enormous amount of invested capital that is dependent to a greater or less extent on incandescent lighting. In view of these facts, it may be well to preface this general account of the situation by some description of the patent on which the suit is brought, and that in certain respects seems the key to the situation.

The patent under consideration was granted to Thomas A. Edison on Jan. 27, 1880, on an application dated some months before, and it is contended by the complainant that the claims have been allowed covering the modern incandescent lamp with which we are to-day familiar as a means of household lighting. Our cut is a fac-simile of the drawings given with the patent in question.

The specifications and claim may be conveniently divided into two parts. In the first place, they cover specifically a certain form of lamp and construction of carbon, shown very clearly in the drawing, but now abandoned. In the second place, the claims cover in a certain way the forms of incandescent lamps in which a high resistance carbon is inclosed in a hermetically sealed and exhausted vessel of glass. It is on the interpretation of these latter claims that the suit hinges. Verbatim they are as follows: "(1) An electric lamp for giving light by incandescence, consisting of a filament of carbon of high-resistance made as described and secured to metallic wires as set forth. (2) A combination of carbon filaments with a receiver made entirely of glass, and conductors passing through the glass, and from which receiver the air is exhausted for the purposes set forth." These purposes are very obvious. A carbon filament exposed to the air disintegrates almost immediately when brought to incandescence, and lamps filled even with another gas, are not found to have life at all comparable with those exhausted to a high vacuum. In the figure (1) shows a section of the lamp in which are a carbon filament coiled here into a spiral; the thickened ends of the spiral secured to the platinum wires; and the copper leading wires outside the bulb connected to the platinum wires sealed through it. In the figure is shown the tube leading to the vacuum pump, which after exhaustion is sealed off in accordance with the practice of to-day.

Fig. 2 shows a plastic material, and (3) the spiral formed from it after the carbonization ready to have the bulb formed over it. The principal form of carbon used is that composed of plastic mixture of lamp-black and coal tar carbonized after being formed into filaments. The general form of lamp will be recognized as one that is in almost universal use to-day. The carbons are formed in various ways and of various materials. The spiral shape exhibited has been almost entirely abandoned in favor of a simple loop, and the particular material mentioned is not now employed.

In his specification Mr. Edison states, however, that he has carbonized and used cotton and linen thread, wood splints, paper, and carbon in various forms, as well as the particular compound in question. At first sight, and in the present state of the art, it would appear that if a patent covers the Edison incandescent lamp, it also covers all other incandescent lamps, and as a matter of fact, the suit has resolved itself into a litigation to uphold the validity of the patent itself. This is by no means the first time that the question has arisen; the English patent having precisely the same claims as those just given has been in suit twice, first in the case of Edison and Swan United Edison Light Co. vs. Woodhouse & Rawson, and again in the suit of the same company vs. Holland and others. In the first case the patent was sustained both in the original suit and on appeal, but the issue that then arose is not entirely applicable to the present suit. In the first place there was already a union of the Edison and Swan interests, and the Edison patent was then attacked, using the Swan lamp as a defense. Such a plea could not be entered here according to the statute, inasmuch as this lamp was a foreign production and not patented or described. The second claim of the patent was the one on which the decision turned. The second English case was decided adversely to the Edison interests on the ground principally of inefficiency in the specification in that it describes some impracticable methods. This is a better defense under the English law than it is under ours on account of the particular nature of the practice there. On appeal the patent was sustained, reversing the previous decision. There has also been litigation in Germany on the same question, in a suit that was virtually an attack made by the Swan Electric Light Co. in the form of a petition to annul the Edison German patent as invalid in view of the prior state of the art. This case was also won by the Edison Co., but the



Figs. 1, 2 and 3.—Edison Electric Lamp; from the Drawing of U. S. Patent No. 223,898.

next year a suit brought by the Edison Co. against Naglo Brothers, won in the original trial, was lost on an appeal, and the court held that the Swan lamp, which had so often appeared in the question, was not an infringement of the Edison patent. The German decisions, however, are hardly parallel to the English ones, because the claims of the patent were not quite the same. Still another suit on the same subject has been tried in this country. This is particularly interesting, as it involves some of the questions now at issue. A third time the boot was on the other leg, inasmuch as the McKeesport Light Company was attacked by the Consolidated Electric Light Company for infringement of the Sawyer-Man patents. This was virtually a suit against the Edison Company for an infringement of the patents owned by the Westinghouse Company, just as the present one is a direct attack by the Edison Company upon the Westinghouse Company. After a considerable amount of litigation a decision in the case was rendered by Justice Bradley, Oct. 5, 1889, which virtually upset the broad claim of the Sawyer-Man patents. The principal claim of Sawyer and Man was on an incandescing conductor made of carbonized fibrous textile material; the other claims of the patent relating to the arch-shaped form which is now almost universally used. Justice Bradley's decision, although it strongly sustains the Edison claims, specially in the particular of employing a very high resistance carbon, was very emphatic in its opinion regarding the state of the art.

Such has been the legal history of the incandescent lamp case up to the present. The suit now going on was originally instituted something like five years ago, but has dragged its slow length along without any specially vigorous litigation until the present time, the years being consumed in dilatory motions by both sides. Meanwhile the incandescent lamp industry has grown to enormous dimensions. The United States and the Edison companies were formed within a few months of each other long before any action looking toward infringement had been taken by either party, and both the Sawyer-Man claims and Edison claims had been in conflict in the Patent Office during this period; in fact, a large amount of valuable time was wasted in endeavors to get prior claims allowed than had appeared in either the Sawyer-Man or Edison patents now existing. These efforts had come to grief, and the McKeesport suit was therefore brought on the original Sawyer-Man patent, and in default of anything better the present suit is on the original Edison patent. This fact complicates the case considerably, for, as will be seen from the claims we have just given, the Edison patent is thereby somewhat narrowed, inasmuch as the first claim apparently refers to the particular construction of carbon filament mentioned in the specification. It is on the second claim, therefore, that the principal attack is made, and this is intended to cover the high-resistance carbon in an all-glass exhausted receiver, and several very complicated questions naturally arise and they are especially embarrassing on account of the long delay during which the art has progressed to an extent almost immeasurable. It is not easy to say what was meant by carbon filament in 1880, neither is it easy to evaluate the moral effect of decisions like Justice Bradley's on questions raised concerning the state of the art before those claims were promulgated. The strong point of the Edison claims is unquestionably the use of the high-resistance conductor in this particular combination. The patent in question however, had been somewhat ante-dated by Edison himself in a high-resistance platinum lamp. And furthermore, it is not a particularly easy matter to define what was meant in 1880 by high resistance. There is good reason to believe that one Adams, in Boston, had incandescent lamps made entirely of glass and exhausted, with platinum conductors fused through it, and either incandescent themselves or attached to carbon rods that were brought to a white heat by the current. This lamp was not patented or published, and hence loses something of its value as an anticipation. It is, however, a question whether sealing platinum wires through glass in such a case would constitute an invention at all in view of the large use of Geisseler tubes and the general equivalents to these or other forms of hermetical sealing. The broad general claim of the Edison interests is that a high-resistance carbon lamp was the first practical commercial lamp, and only by its use could modern incandescent lighting become a possibility. The Edison lamps, both carbon and platinum, were unquestionably of higher resistance than had previously been used, but, in controversion of this, it may be contested that by 1880 it was pretty thoroughly understood that transmitting devices of whatever kind in an electric circuit should be of high ohmic resistance in order to secure economy and consequently that an application of this general principle to incandescent lamps did not necessarily imply invention. In the next place, it seems somewhat a matter of doubt as to whether the commercial success of the incandescent lamp did or did not depend on a filament or anything like as high resistance as is now employed. This question again becomes tangled up with the developments in the art during the last few years, which, albeit they have no legal value, have a moral effect that is not to be neglected.

Finally, as a sort of side light of considerable importance in litigation, is the undoubted effect of the name of Thomas Alva Edison as inventor. His labors in connection with the electric light field are too widely known and too important not to produce a moral effect in weighing the evidence that is presented.

To sum all the points of litigation, the strong claim of the Edison patent is the second, involving the carbon high resistance filament inclosed in an exhausted glass globe and furnished with a current from conductors sealed through the glass. This claim has stood fire pretty successfully in England, and is the broadest claim that is ever likely to appear in incandescent lamp litigation. The defense is lack of invention and lack of novelty in the Edison patent in view of the previous state of the art, lack of invention in the use of the high-resistance carbon filament, and, in fact, in the substitution of carbon for the high resistance platinum of the previous lamp, and lack of novelty in the use of the exhausted globe and wires sealed through the glass in view of previous investigations. The general use of carbons in the manner ordinary in incandescent lamps is put on pretty plain grounds by Justice Bradley's decision. The effect of increasing its resistance on the legal aspects of the question is somewhat hazy. Nevertheless, the patent has been sustained in two distinct suits, and therefore has a certain presumption in its favor. The present litigation is not necessarily the end by any means, for an appeal is possible to the Circuit Court of Appeals about to be organized under a recent statute; and thence possible even to the Supreme Court of the United States. The interests involved are of such tremendous magnitude that every legal resource will be exhausted before either party gives in. The present case necessarily will have an importrnt bearing in any future action.

Modern Central Stations of Siemens & Halske in Berlin, Germany.

BY ALEXANDER VON BABO.

Although Mr. Edison constructed his well-known "steam dynamo" for the central station in New York, strangely enough Americans seem to have forgotten the great advantage to be gained in central stations by avoiding belt gearing. This fact seems more strange, indeed, considering that America, up to the present day, stands at the front in the construction and use of high speed steam engines, and that the main difficulty of direct coupling of dynamos consists in reconciling the different speeds of dynamos and engines. Thus it seems that while central station lighting has been taken up, and developed ever so much more quickly in America, the electricians of the old country have taken so much more time about thinking over every detail of a generating station before having gone to work, and in this way have developed a style of machinery differing as widely as possible from the constructions in general use in America, considering that the objects of both are identical.

The accompanying illustrations are intended to give an idea of the generating plant of a modern European central station. They are taken from photographs of the largest Berlin station, which is situated at Spandauerstr. and built for the Allgemeine Elektricitäts Gesellschaft of Berlin by the well-known firm of Siemens & Halske. The Allgemeine Elektricitäts Gesellschaft, formerly the German Edison Company, favors low tension and direct distribution by the three-wire system. It has gradually supplied the greater part of the German metropolis with a system of feeders and mains constructed of lead covered and iron armored cables. Up to the present date about 400 miles of these cables have been furnished and laid by Messrs. Siemens & Halske.

The whole of this distributing system is now fed by four generating stations, which are located at Mauerstr., Markgrafenstr., Spandauerstr. and Schiffbauerdamm. That at Spandauerstr. is at present the largest, although it will soon be surpassed by the station on the Schiffbauerdamm.

The station in Spandauerstr. alone will have a capacity of 40,000 16-candle lamps, and at present actually feeds about half that number. The current in this plant is generated by only four large steam dynamos of 1,000 h. p. each. It would at first seem as if the subdivision of the plant into four generators were not sufficient. The whole distributing system, however, is so arranged that, though each of the four above mentioned stations has its own system of feeders and mains, these four distributing systems are connected by special cables; consequently in daytime, when little light is required, the Spandauerstr. station, for instance, can be shut down entirely, the current being then supplied by one of the other stations. Thus it is possible to run one or more of the four 1,000 h. p. engines of Spandauer station either at full load or not at all. The use, however, of these large low-speed engines, when not fully loaded, is found to be still more economical than it is to employ a great number of small high-speed engines and dynamos, as is done in the older stations at Mauerstr. and Markgrafenstr. A large low-speed engine requires less attendance, so that the saving in wages and lubrication amply compensate for the loss incurred should the necessity turn up to run the 1,000 h. p. engine with half its normal load.

Fig. 1 shows the peculiar construction of the 1,000 h. p. steam dynamos. The engines are vertical compound condensing of the Corliss type, built by Messrs. Van den Kerchove, of Ghent.

In order to economize building space vertically built engines have been preferred, and although the total height of these engines is about 25 feet, the boilers have been arranged on the floor above them.

To each engine are coupled two speed dynamos, each wound for an output of 2,500 ampères at 140 volts. This plan of dividing into two individual machines the dynamos coupled to one engine, not only gives great symmetry and a handsome appearance to the whole arrangement, but greatly contributes to the evenness of the motion of the engines, since both cranks are at all times equally loaded.

The dynamos themselves are of a peculiar and novel construction, especially devised for this kind of service by Messrs. Siemens & Halske.

The first object in constructing these machines was to choose for their working speed the most economical speed of the engines. This result was achieved by giving each dynamo a number of pole pieces sufficient to reduce its speed to about 65 revolutions per minute. This principle led to the construction of a star-shaped electromagnet, enclosed by a ring armature. By such a disposition two equally important points are gained. The armature circumference being the part farthest removed from the axis, acquires the necessary velocity at a relatively small angular speed, and at the same time the magnetic disposition of the iron is the best imaginable. On the other hand it will be noted that this arrangement allows a very close connection with the motor. For this purpose the star-shaped electromagnet is simply bolted to the framework of the engine, as shown in Fig. 1. In Fig. 2 two of the ten pole pieces or field magnets are visible between the spokes of the ring-shaped armature. The armature itself is supported by a cast-iron boss, carrying 40 spokes, which in its turn is fitted to the shaft of the engine. The brushes are made to slide directly on the winding of the armature and no commutator whatever is therefore required.

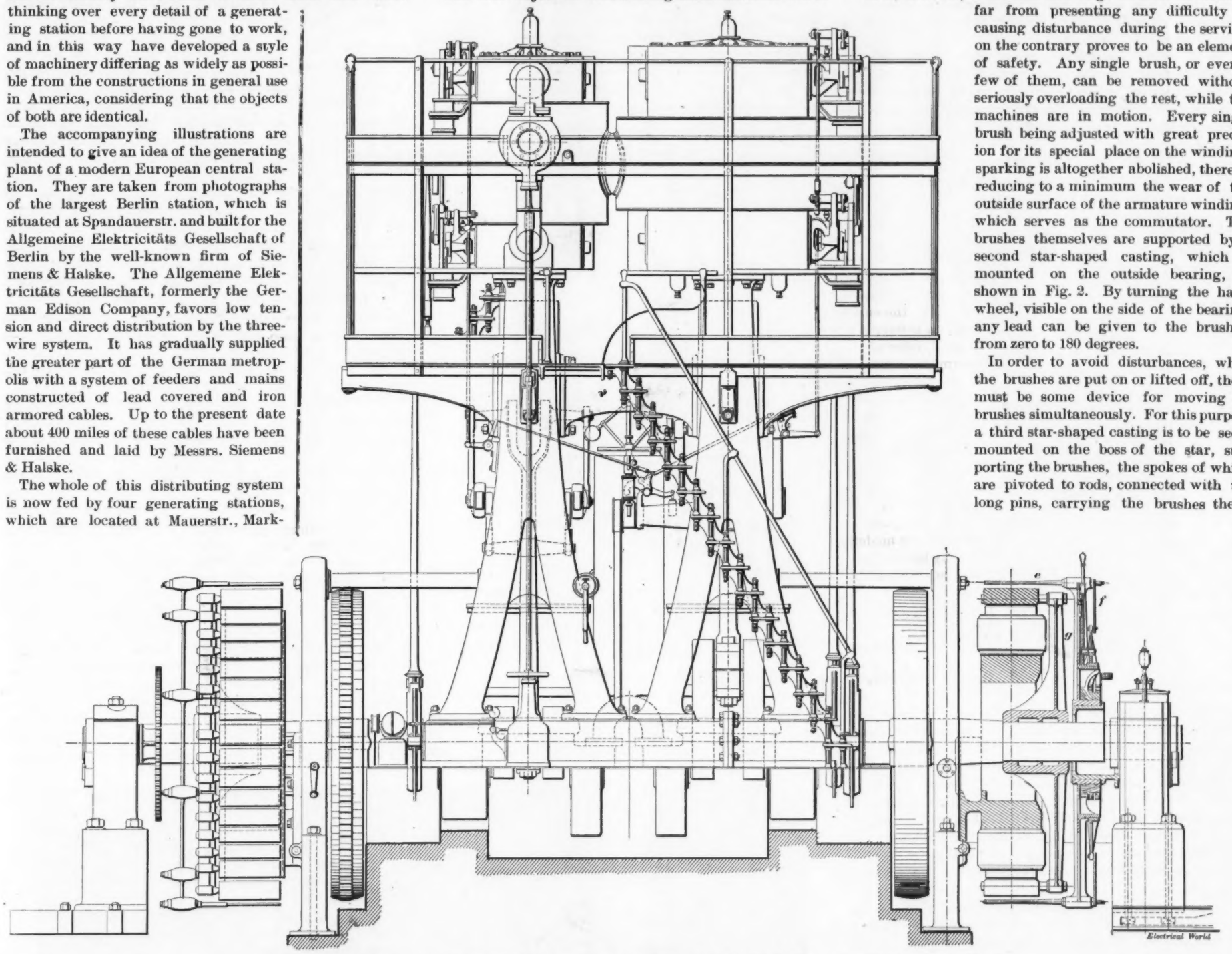


FIG. 1.—SIEMENS & HALSKE STEAM DYNAMO USED IN CONTINENTAL CENTRAL STATIONS.

The construction of these large dynamos is in this way reduced to the simplest form, offering at the same time still another advantage: should any single winding fail, it is perfectly easy to remove the bad winding and replace it by another without dismounting any other part of the machine. By doing away with the commutator the internal resistance is materially reduced.

This form of dynamo has the further advantage of having all parts easily accessible; when in motion they can not only be closely examined, but even touched.

These advantages are so much appreciated, that although this type was introduced by Messrs. Siemens & Halske barely two years ago, more than a hundred of these machines, varying in capacity from 70 to 500 h. p., are at present at work in different cities of Europe. About half of them were built in the works of this firm at Charlottenburg, near Berlin.

Since simplicity of design is the main object aimed at in the construction of these machines, the armature winding is invariably executed as a simple helix, without any internal connections whatever. Thus the necessity becomes apparent of employing as many sets of brushes as there are pole pieces, that is, ten in the present case.

It is, however, found that this large number of brushes, far from presenting any difficulty or causing disturbance during the service, on the contrary proves to be an element of safety. Any single brush, or even a few of them, can be removed without seriously overloading the rest, while the machines are in motion. Every single brush being adjusted with great precision for its special place on the winding, sparking is altogether abolished, thereby reducing to a minimum the wear of the outside surface of the armature winding, which serves as the commutator. The brushes themselves are supported by a second star-shaped casting, which is mounted on the outside bearing, as shown in Fig. 2. By turning the hand wheel, visible on the side of the bearing, any lead can be given to the brushes, from zero to 180 degrees.

In order to avoid disturbances, when the brushes are put on or lifted off, there must be some device for moving all brushes simultaneously. For this purpose a third star-shaped casting is to be seen, mounted on the boss of the star, supporting the brushes, the spokes of which are pivoted to rods, connected with the long pins, carrying the brushes themselves. It will be noted that by moving the lever, which works this third star-shaped casting by tooth gearing, the pins carrying the brushes will all be turned at the same time and in the same direction, so that either all brushes are put on or lifted off the surface of the armature ring from the dynamo terminals situated above the bearing, the current is taken up by a pair of flexible cables T_1 and T_2 in Fig. 2 leading to the copper bars overhead, which form the connections with the switchboard. The switchboard itself is a large wrought-iron framework. The accompanying illustration Fig. 3 gives a view of that part of the framework on which the switches necessary for the present service are mounted, covering but half the room intended for the complete switchboard. On the left side are seen four large double switches, for switching any one of the four dynamos at present in use, current indicators of a capacity of 3,000 ampères being inserted in the bars leading to the switches. With the aid of a hand wheel, found below every switch, resistance is inserted in the shunt windings of each dynamo. As the current passing through the shunt winding of each dynamo has an intensity of about 40 ampères, and as the extra current by self-induction, when breaking this circuit, would be very strong, it was found advisable to construct a special device similar to a large arc lamp for interrupting the current.

The electrodes of this device are ordinary carbons, which can easily be replaced when burned up. On inter-

rupting the magnetizing current an arc is formed, which is drawn out to such a length that the current diminishes gradually till the arc is extinguished. Above the current indicator are placed differential voltmeters; one for each

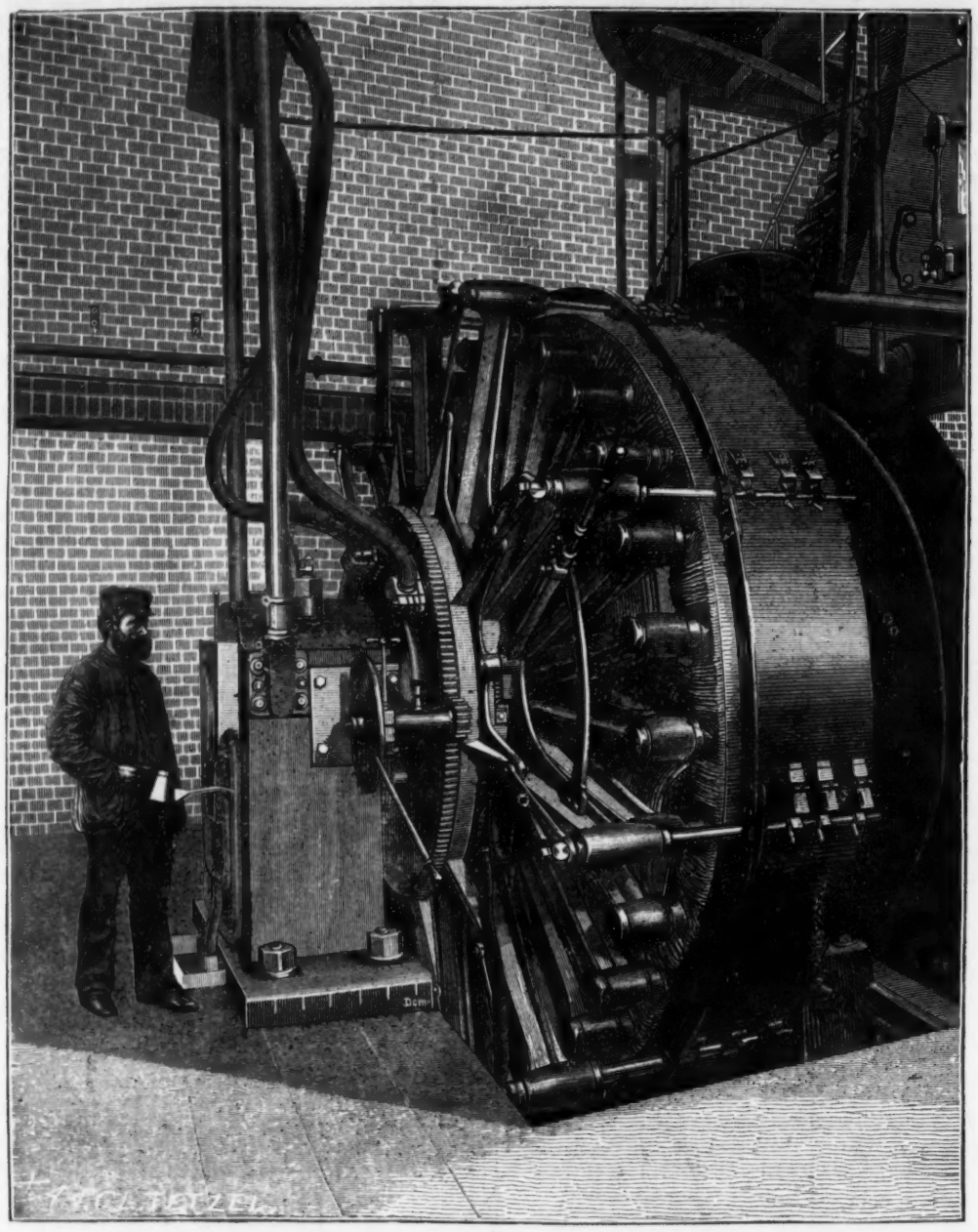


FIG. 2.—SIEMENS & HALSKE DYNAMO.

dynamo, indicating the potential difference of each one separately, and another indicating the potential of those dynamos already connected with each one in parallel.

Thus when it is desired to switch on a new machine its potential difference is regulated at first in such a way that its own differential voltmeter reads zero, which shows that it may now be safely connected with the others. The three horizontal copper bars lead to a set of resistances which are so dimensioned as to be sufficient to take up the whole current generated by a 1,000 h. p. engine and its two dynamos.

These resistances are employed for trials. Apart from the switchboard, so as not to be influenced by the strong currents and by mechanical disturbances, are placed the voltmeters, which indicate the potential difference at the lamps. Only four of them are used for the whole distributing system which is fed by the central station at Spandauerstr., and which covers an area of about three square kilometres. Two of these voltmeters indicate the mean potential difference found between the conductors of the three-wire system in all junction or distributing boxes combined. The other two can be connected at will with the conductors of any one of the junction boxes, showing then the potential difference at but one of the 36 boxes of this system.

It will be perceived that the idea which guided the German electricians in developing these devices was the desire to simplify the service as much as possible, even if the first cost of a central station was materially increased thereby. The same principle was followed in calculating the cross sections of the feeders, which vary in length from 100 to 1,500 yards. No adjustable resistances whatever are necessary in the feeders for compensating the influence of variation of load, caused by the changing consumption at different hours of the day. By using somewhat heavier copper sections the whole distributing system was made self-regulating to such a degree that the greatest possible deviation from the normal pressure will never be more than plus or minus 1.5 volts, *i. e.*, as long as the pressure at the dynamo terminals is kept constant. The distributing system for this station was being laid in the summer of 1889, at which time Mr. Edison on his European tour visited Berlin. On being invited by Dr. Werner von Siemens to inspect it, the distinguished foreigner expressed great satisfaction in regard to the system employed and the cables used. Messrs. Siemens & Halske, at request of the Berliner Elektricitäts-Werke, employed three single cables, instead of their otherwise used patented concentric cables with three conductors. The cables consist of the necessary number of copper wires, stranded together, and containing, invariably, one so-called test wire, which, carefully insulated from the other wire, is used for the measurements described above.

The stranded copper cables are insulated with jute

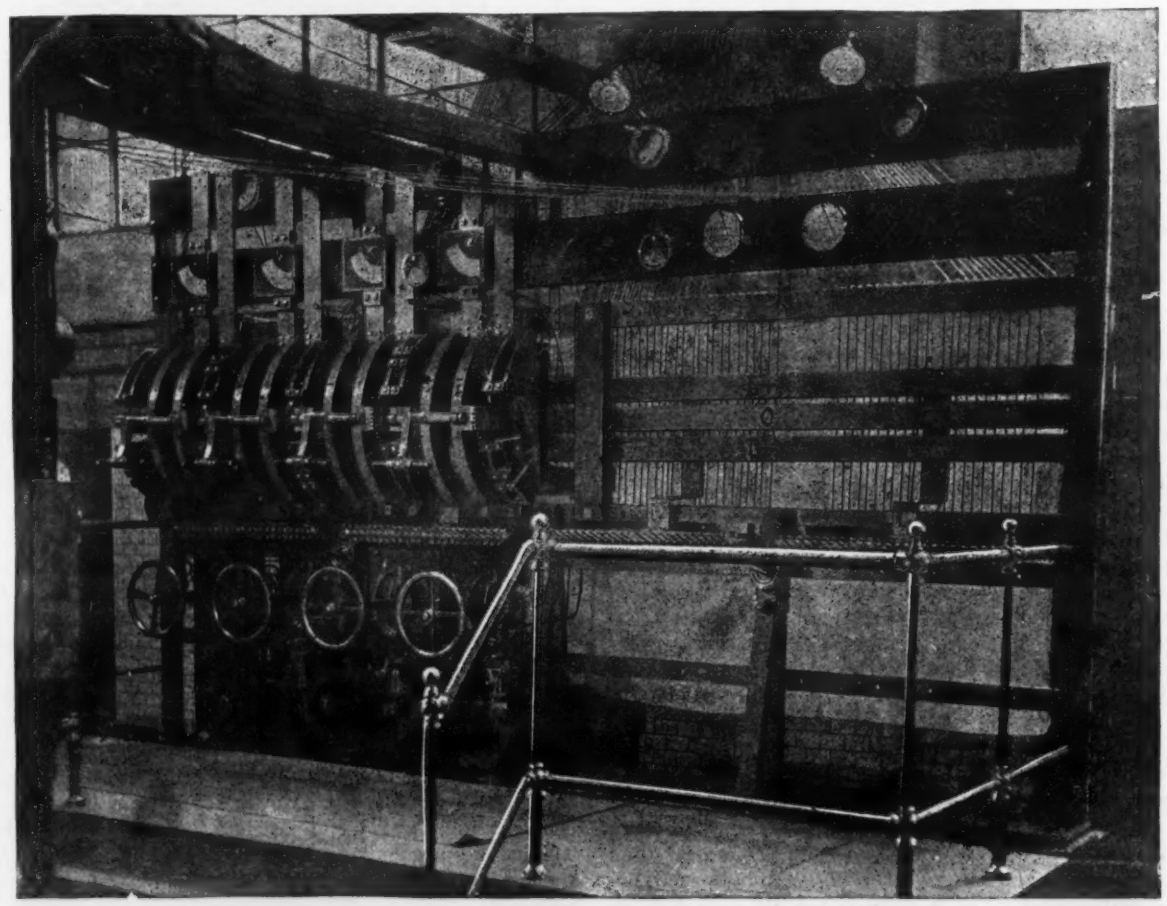


FIG. 3.—SIEMENS & HALSKE SWITCHBOARD.

soaked in compound and covered with lead. The lead-or satisfactory knowledge of the thing vntill such time as covered cables are, in their turn, protected with asphaltedit pleased God to raise vp one of our countrymen *D. Gil-* jute and sheathed with two layers of iron tape. These*bert*, who to his euerlasting praise hath trodden out a new cables are laid directly into the ground without any fur-path to *Philosophie*, and on the Loadstone, erected a large ther protection or conduits. Cast-iron junction boxes are *Trophie* to commend him to posterity. This famous Doctor provided at all important points, and are placed on small

special foundations of masonry, and so located under the sidewalks that by lifting up a stone slab every box can easily be reached and inspected. These boxes are made absolutely airtight great care being taken to secure perfect dryness before closing them up. Every one of them contains a number of safety fuses, so that by opening two boxes and removing the fuses, every part of the system can, at any time, be cut out for repairs or other purposes. Up to the present date about 9,000,000 feet of these cables have been put down by Messrs. Siemens & Halske, and are satisfactorily working in many cities and towns all over Europe.

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Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C. 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

A. D. 1621.——Helmont (Jean Baptiste van), famous Belgian scientist, publishes in Paris his "De Magnetica, etc." on the magnetic cure of wounds). His theories on magnetism closely resemble those of Paracelsus, but in his treatment of them he shows himself much superior to the Swiss alchemist whom Dr. Hoofer says, "he took in some measure as his model." "Magnetism," Van Helmont observes, "is an unknown property of a heavenly nature, very much resembling the stars, and not at all impeded by any boundaries of space or time. . . . Every created being possesses his own celestial power and is closely allied with heaven . . . the spirit is everywhere diffused, and the spirit is the medium of magnetism . . . it is not the spirits of heaven and of hell which are masters over physical nature, but the soul and spirit of man which are concealed in him as the fire is concealed in the flint."

See "Ency. Brit.," ninth ed., vol. XI., p. 638, and Larousse, "Dict. Univ.," vol. IX., p. 158.

A. D. 1624.—Gunter (Edmund), professor of astronomy at Gresham College, publishes his work, "Of the Sector, Cross-Staff, and other Instruments," at chapter V. of the second book of which he gives the result of the eight observations he made on the variation of the variation "in various parts of the ground," at Limehouse, on the 13th of June, 1622. His observations of the declination, as given by Prof. Gallibrand, are detailed at chapter I. of Walker's "Ter. and Cos. Mag.," Cambridge, 1866.

See, also, De La Rive, "Electricity, etc.," vol. I., p. 165. Poggendorff, "Geschichte der Physik," Leipsic, 1879, p. 275.

A. D. 1625.——Carpenter (Nathaniel), dean of Ireland, well known mathematician, publishes, at Oxford, "Geography delineated forth in two bookes, containing the sphaericall and topicall parts thereof," wherein he thus alludes to Dr. Gilbert's "De Magnete" (see A. D. 1600): "Magneticall proprieties, I find in ancient Writers, as little knowne as their causes; and if any matter herein were broached, it was merely coniectural, and depending on no certain demonstration: neither had we any certain

*Continued from THE ELECTRICAL WORLD, May 30, 1891.

being as pregnant in witty apprehension as diligent in curious search of naturall causes, after many experiments and long inquiry, found the causes of most magneticall motions and proprieties hid in the magneticall *temper* and constitution of the *Earth*, and that the earth it selfe was a meere *magneticall* body challenging all those proprieties, and more than haue expressed themselves in the Loadstone; which opinion of his was no sooner broached than it was embraced and wel-commed by many prime wits as well *English* as *Forraine*. Insomuch that it hath of late taken large root and gotten much ground of our *Vulgar Philosophie*."

A. D. 1625.——Naudé (Gabriel), a celebrated French savant and one of the most learned men of his day, also physician to King Louis XIII. and an intimate friend of Gassendi, is the author of "Apologie pour tous, etc." (Apology for great men falsely accused of magic), of which other editions appeared in 1652, 1669 and 1712. The magico-theosophical philosophy, as Madame Blavatsky expresses it, is fully indicated in his work, and he proved to be the warmest defender of the doctrines of occult magnetism, of which he was one of the first propounders.

See "Biog. Générale," tome XXXVII., pp. 514–518.

A. D. 1627.——Hakewill (George), D. D., Archdeacon of Surrey, publishes at Oxford, England, the first edition of "An Apologie . . . ," the tenth chapter, fourth section of the third book of which alludes to the use of the "mariner's compasse or sea-card, as also of another excellent invention sayd to be lately found out upon the loadstone." As the reviewer justly observes, "While perusing his description one can hardly imagine that the writer had not in his mind's eye one of our modern telegraphic instruments; . . . and it will be seen that the date at which his work is written was nearly two hundred years prior to the first attempt made to communicate at a distance by means of magnetic needles."

A. D. 1628.——Leurechon (Jean), a student belonging to the order of Jesuits, publishes, under the name H. Van Etten, "La Récréation Mathématique," carefully revised editions of which were made by Claude Mydorge and Denis Henrion in 1630, 1638 and 1661. In these Leurechon alludes to the reported transmission of intelligence by the agency "of a magnet or other like stone," saying: "The invention is beautiful, but I do not think there can be found in the world a magnet that has such a virtue."

See *Sc. Am. Suppl.*, Nos. 384, page 6,125, and 56, page 881.

A. D. 1629.——Cabeo—Cabæus (Niccolas), a learned Jesuit of Ferrera, describes ("Philosophia Magnetica") many experiments made by him with magnets to ascertain the possibility of two persons communicating intelligence by means of magnetized needles.

In the tenth chapter of the above-named work he thus expresses himself: "Magnetic attractions and repulsions are physical actions which take place through the instrumentality of a certain quality of the intermediate space, said quality extending from the influencing to the influenced body. . . . Bodies are not moved by sympathy or antipathy, unless it be by means of certain forces which are uniformly diffused. When these forces reach a body that is suitable they produce changes in it, but they do not sensibly affect the intermediate space nor the non-kindred bodies close by it. . . ."

The "Philosophia Magnetica" is the second Latin book published on electricity, Gilbert's "De Magnete" being the first.

See Becquerel, "Résumé," chap. III.; "Description de l'Aimant, etc.," par L. L. de Vallemont, 1692, pp. 167, 170.

A. D. 1632.——Gassendi (Pierre), an eminent French savant, professor at the Royal College of France, "ranked by Barrow among the most eminent mathematicians of the age, and mentioned with Galileo, Gilbert and Descartes," discovers that a part of the iron cross of the Church of Saint Jean at Aix possesses all the properties of a loadstone after being struck by lightning and lying in one position a certain length of time. Gilbert mentions that the fact of magnetism being imparted to an iron bar by the earth was first ascertained by examining the rod upon the tower of the Church of the Augustines at Mantua.

In the "Vie de Pierre Gassendi, par le père Bougerel de l'Oratoire, Paris, 1737," page 14, it is related that: "During the month of September, 1621, while promenading, at about three leagues from Aix, in a village named Peynier, he observed a light in the heavens to which he gave the name of *Aurora Borealis*, as much by reason of its location as on account of its resemblance to the light which precedes the rising of the sun."

See Enfield, "Hist. Phil.," vol. III, p. 430; Lardner, vol. II., p. 113; "Cosmos," vol. II., p. 718, and vol. V., p. 132; Cæsar, A. D. 1590.

A. D. 1632.——Galileo (Galileo Galilei), Italian philosopher and mathematician, publishes his celebrated "Dialogus de Systemate Mundi," 4to, Fiorenza, from page 88 of which is extracted the following passage:

"*Sagredus:* You remind me of a man who offered to sell me a secret for permitting one to speak, through the attraction of a certain magnet needle, to some one distant two or three thousand miles, and I said to him that I would be willing to purchase it, but that I would like to witness a trial of it, and that it would please me to test it, I being in one room and he being in another. He told me that, at such a short distance, the action could not be witnessed to advantage; so I sent him away and said that I could not just then go to Egypt or Muscovy to see his experiment, but if he would go there himself I would stay and attend to the rest in Venice."

This *Sagredus* (Iohannes Franciscus), or Sagredo (Giovanni Francisco), besides being "a great magneticall man," was a noble Venetian, even a doge, and had represented his country as ambassador at several courts. We read in Mr. Conrad W. Cooke's very able article on "William Gilbert, of Colchester," printed in *Engineering*, London, December, 1889, that this same Sagredus was the intimate friend of Galileo, and that, together with the powerful Sarpi, he used the whole might of his name and influence to protect the great philosopher and mathematician from the attacks of the clerical party. Pietro Sarpi, otherwise known as Father Paul, was a most illustrious Venetian scholar, who attained great proficiency in the medical and physiological sciences as well as in mathematics and in natural philosophy, but is principally celebrated for his "History of the Council of Trent," "the rarest piece of history the world ever saw." Sagredus made important researches in magnetism, and, while on a voyage to Aleppo, determined the declination of the magnetic needle at that place. As a tribute to the scientific attainments of Sagredus, Galileo immortalized him by selecting his name for one of the characters in his "Systema Cosmicum," and many references to the work by William Gilbert are put into the mouth of "Sagredus."

In further illustration of Galileo's appreciation of Gilbert, we will here quote the great astronomer's own writing. "I extremely admire and envy the author of 'De Magnete.' I think him worthy of the greatest praise for the many new and true observations which he has made, to the disgrace of so many vain and fabling authors, who write not from their own knowledge only, but repeat everything they hear from the foolish and vulgar, without attempting to satisfy themselves of the same by experience; perhaps that they may not diminish the size of their books." (Drinkwater's "Life of Galileo.")

Galileo had also published, in 1630, the first edition of his "I discorsi e demonstrazioni, etc.," which Lagrange considers to be Galileo's most substantial title to scientific glory.

See his biography in "Engl. Cycl.," vol. III., pp. 13–17; Miller, "History Philosophically Illustrated," London, 1849, vol. III., p. 203, note.

A. D. 1635.——Delambre (J. B. J.)—(1749–1822)—professor of astronomy at the Royal College of France, refers (vol. II., p. 545, of his "Histoire de l'Astronomie Ancienne," 1817) to the mention made in "Procli Diadochi Paraphrasis Ptolem." lib. IV., "de Siderum affectionabus," 1635, p. 20, of the notion long current, especially along the shores of the Mediterranean, "that if a magnetic rod be rubbed with an onion, or brought into contact with the emanations of the plant, the directive force will be diminished, while a compass thus treated would mislead the steersman."

See "Cosmos," vol. V., p. 156; A. D. 1653. See also Whewell, "History of the Inductive Sciences," vol. I., pp. 442, 443, 447, and biography in the Supplement of the "English Cyclopædia," pp. 539–541.

A. D. 1635.——Gellibrand (Henry), prominent English mathematician, professor of geometry at Gresham College, discovers the *secular variation of the declination*. The *diurnal variation* was found by Graham in 1722, and the *annual variation* was discovered by Cassini, 1782–1791.

Gellibrand's discovery is published in a small quarto pamphlet entitled "A discourse mathematical on the variation of the magnetical needle—together with the admirable diminution lately discovered," and is the result of his careful study of the observations made by Burroughs and Gunter, as well as of others made by himself, all of which showed that the northeast of the needle was gradually moving to the westward.

See Walker, "Magnetism," chap. 1; John Pell, "Letter of Remarks on Gellibrand's Math. Disc.," 1635.

A. D. 1641.——Wilkins (John), Bishop of Chester in the reign of Charles II., publishes the first edition of "Mercury, or the secret and swift messenger, showing how a man with privacy and speed may communicate his thoughts to a friend at any distance."

In the above, he thus alludes to the possibility of making a contrivance similar to our modern telegraph: ". . . There is another experiment . . . mentioned by Walchius, who thinks it possible so to contrive a trunk or hollow pipe that it shall preserve the voice entirely for certain hours or days, so that a man may send his words to a friend instead of his writing. There being always a certain space of intermission, for the passage of the voice, betwixt its going into these cavities and its going out; he conceives that if both ends were seasonably stopped, while the sound was in the midst, it would continue there till it had some vent. 'Huic tubo verba nostra insusurremus, et cum probe munitur tabellario committamus, etc.' When the friend to whom it is sent shall receive and open it, the words shall come out distinctly, and in the same order wherein they were spoken. From such a contrivance as this (saith the same author) did Albertus Magnus make his Image, and Friar Bacon his Brazen Head, to utter certain words."

In the eighteenth chapter, he makes suggestions for "a language that may consist of only tunes and musical notes, without any articulate sound."

He had previously described a novel mode of telegraphing by the use of only three torches to indicate the necessary twenty-four letters of the alphabet. These letters were, in accordance with the plan of Joachimus Fortius, to be placed in three classes of eight each. One torch denoted Class I., two torches Class II., and three torches Class III., and the number of the letter was indicated by the number of times the torch (or light) was elevated or displayed.

Bishop Wilson also described a method of telegraphing by means of two lights attached to long poles, which, he says, "for its quickness and speed is much to be preferred before any of the rest." To interpret messages at long distances he suggested the use of the then newly invented telescope, which he called "Galileus his perspective."

See the third edition of above-named work, 1707, chap. XVII., pp. 71, 72, also the fifth edition of Wilkins' "Mathematical Magic," London, 1707, chap. XIII., pp. 147–150, "concerning several attempts of contriving a perpetual motion by magnetical virtues."

A. D. 1641.——Kircher (Athanasius), a German writer on physical and mathematical science, possessed of immense erudition, and believing in the magnetism of all things, speaks, in his "Magnes, sive de arte magnetica" (book II., part IV., chap. V.), of the recently advanced idea of being able to correspond at short distances by employing two spherical vessels bearing the letters of the alphabet, each of the letters having suspended from it a magnetized figure attached to a vertical wire.

He likewise alludes to Gellibrand's discovery, A. D. 1635, of which he was informed by John Greaves, the eminent English mathematician, and he communicates a letter received from the learned French philosopher, le Père Marin Mersenne, containing a distinct account of the same.

His definition of magnetism, according to Madame Blavatsky, is very original, for he contradicted Gilbert's theory that the earth was a great magnet. He asserted that, although every particle of matter, and even the intangible "powers," were magnetic, they did not themselves constitute a magnet. *There is but one magnet in the universe, and from it proceeds the magnetization of everything existing.* This magnet is, of course, what the Kabalists term the central Spiritual Sun, or God. . . . He demonstrates the difference between mineral magnetism and zoömagnetism, or animal magnetism, and says that the sun is the most magnetic of all bodies. . . . it imparts the binding power to all things falling under its direct rays. ("Isis Unveiled," pp. 208–210.)

See Kircher, "Ars Magnetica sive conclusiones, etc.," Wurtzburg, 1631; Ninth "Britannica," vol. XIV., p. 93.

A. D. 1644.——Digby (Sir Kenelm), the very famous Englishman to whom allusion has already been made under the A. D. 600–580 date, publishes, in Paris, "Two Treatises, in the One of which the Nature of Bodies, in the other the Nature of Man's Soule is looked into: in Way of Discovery of the Immortality of Reasonable Soules." In a chapter of this work, entitled "Of the loadstone's generation and its particular motions," appears the following interesting reference to Gilbert's work and reputation, as reproduced in Mr. Conrad W. Cooke's able article published in *Engineering* before alluded to: "But to come to experimentall proofes and obseruations vpon the loadstone by which it will appeare that these causes are well esteemed and applyed, we must be beholding to that admirable searcher of the nature of the loadstone, Doctor Gilbert: by means of whom and of Doctor Haruey, our Natio may claim euen in this latter age as deserued a crowne for solide Philosophicall learning as for many ages together it hath done formerly for acute and subtile Speculations in Diuinity. But before I fall to particulars, I thinke it worth warning my Reader, how this great man arriued to discouer so much of Magneticall Philosophy; that he likewise, if he be desirous to search into nature, may by imitation advance his thoughts and knowledge that way. In short, then, all the knowledge he gott of this subject was by forming a little loadestone into the shape of the earth. By which meanes he compassed a wonderfull designe, which was to make the whole globe of the earth maniable; for he found the properties of the whole earth in that little body; which he therefore called a Terrella, or little earth; and which he could manage and trye experiences vpon att his will. And in like manner, any man that hath an ayme to aduance much in naturall sciences, must endeauour to draw the matter he enquireth of, into some such modell, or some kinde of manageable methode: which he may turne and wind as he pleaseth. And then lett him be sure, if he hath a competent vnderstanding, that he will not misse of his marke."

In the second edition of Digby's "The Immortality of Reasonable Sovles" ("a treatise on the soul proving its immortality"), published during the year 1645, are to be found attractive portraits of himself and of his wife, Venetia Anastasia Stanley, daughter of Sir Edward Stanley, of Tongue Castle, one of the celebrated beauties of her day.

See Emerson's Works, London, 1873, vol. 2, p. 35.

A. D. 1650.——Bond (Henry), professor of mathematics in London, is the author of "The Seaman's Circular," as well as of "The Longitude Found," wherein he explains his discovery of the progress of the deviation of the compass and foretells the variations for London, 1663 to 1716.

See De Humboldt's "Cosmos," vol. I., p. 187, vol. II., p. 658, vol. V., p. 58, and his "Examen Critique de l'Hist. et de la Géographie," vol. III., p. 60; *Phil. Trans.* for October 19, 1668, p. 790.

Armature Reaction in Constant Current Dynamos.*

BY PROF. H. S. CARHART.

The experimental work of a laboratory of electrical engineering convinces the observant investigator that the literature of dynamo-electric machinery is not only deficient in matters pertaining to constant current machines, but contains reiterated statements that are wide of the facts. Thus we are told that regulation by means of the movement of the brushes round the commutator cylinder is impracticable because of the destructive sparking that ensues; while the fact is that with machines having a closed-coil armature, and particularly those of the Gramme ring type, the current may be kept constant from full load to no load by rocking the brushes forward without any appreciable sparking. The explanation of this remarkable method of regulation is the enormous influence of the armature on the magnetic circuit of the machine. At the same time it must be confessed that uniformity of field contributes to the result, but great uniformity is not essential.

My remarks will be directed, not so much to the explanation of the sparkless commutator of a machine which regulates by rocking the brushes round the commutator cylinder, as to the part played by the magnetism of the armature of a constant current dynamo.

In the ideal simple dynamo the lines of force are supposed to traverse the interspace lying in their path between the polar faces and the armature core with almost perfect uniformity in every part. But it is well known that this is only approximately true even when the field magnet is independently excited and the armature is at rest with no currents flowing through it. A deformation and redistribution of the lines of force begin as soon as the armature is set in rotation, unless the lamination is carried to an extreme, and the brushes are not down so as to short-circuit sections of the coil as they pass under them.

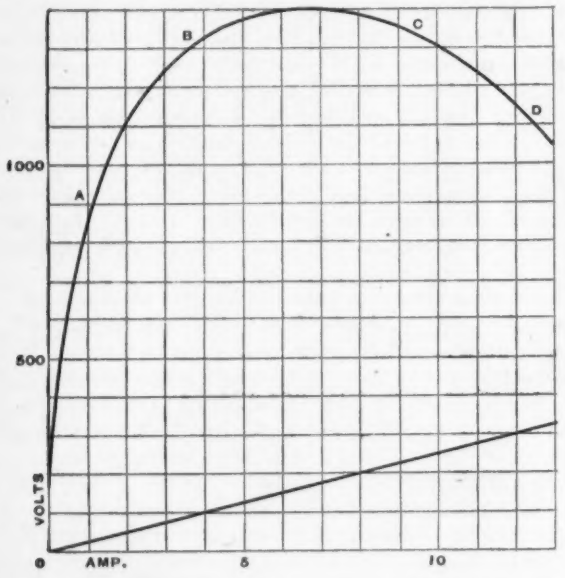


Fig. 1.—Characteristic Curve of a 25-Light Dynamo.

With the machine self-excited, and the external circuit closed, so that a current circulates round the armature, then the "Battle of the Giants" begins. For the armature core is magnetized both by the induction from the field and the current circulating through its own coils. In other words, the flux of magnetic force through the armature is the result of two magneto-motive forces. The relative influence of the one generated in the armature itself will depend upon the design and construction of the machine in a manner which I shall now proceed to explain.

Constant potential dynamos and constant current dynamos possess diametrically opposite properties in those particulars which affect armature reaction. It is essential in the first place that the armature resistance of the former should be reduced to the lowest limit of making a very intense field and by reducing the convolutions of wire to as small a number as possible, hence the magnetic effect of the armature is reduced to small limits for this reason.

Again, every builder of dynamos knows that the field cores and pole pieces of constant potential machines should be heavy in comparison with those of constant current machines. The iron in such machines must be kept below the so-called saturation point, even at full load, so that the field will respond by the series winding to the increasing load with additional lines by force, and thus make up for the increased loss of potential in the armature. Whenever, therefore, the current increases in such a machine, the field magnet responds to the increase to an extent fully equal to that of the armature. The relative influence or reaction of the armature is thus kept within narrow limits.

The well-designed constant current machine is very different from all this. Fig. 1 is a "characteristic curve" made from a 25-light machine with a Gramme ring. It is simply a curve drawn with the currents and the volts at the terminals as co-ordinates. This curve exhibits both the saturation of the field magnet cores and the reaction of the armature. It will be observed that at 10 ampères the curve is well over its maximum and the reactionary droop has set in. Such a curve, when corrected for internal loss of E. M. F., represents approximately the curve of magnetism of the field.

Now a constant potential machine works on the rising part of the curve as from *A* to *B*, so that the field magnet may respond promptly to the rising current. The magnetism is just at that exquisitely sensitive stage when it feels every change in the current, and when the permeability has a nearly constant value. The constant current machine, on the other hand, works preferably to the drooping part of the curve between *C* and *D*. It thus becomes in a measure inherently self-regulating or automatic, for any increase in the current actually diminishes the E. M. F., thus checking the rise of current, while a decrease of current causes the point traversing the characteristic to move backward along the curve and thus upward. The consequent rise of voltage tends to sustain the current at its normal value. This feature of a constant current machine permits of larger armature reactions, and, moreover, gives to the machine that stability so essential to prevent surging, when the machine is run on arc lights. If the machine were working on the outer side of the bend or crown of the curve, any sudden increase in lamp resistance at the carbons, such as often occurs, reduces the current and so reduces the ampère turns round the field magnet, thus causing the point denoting voltage to run rapidly down the curve on the left. The trouble is thus cumulative, and the machine drops its load by losing its excitation, to recover it again only after the carbons have dropped together. The drooping characteristic gives to a series arc machine a stability and self-control which enable it to check small irregularities of circuit resistance. It is, in other words, stable (instead of instable). The field magnets of such a machine are not greatly sensitive to moderate changes in the current. It possesses that self-corrective property so essential to steady working on good arc lamps.

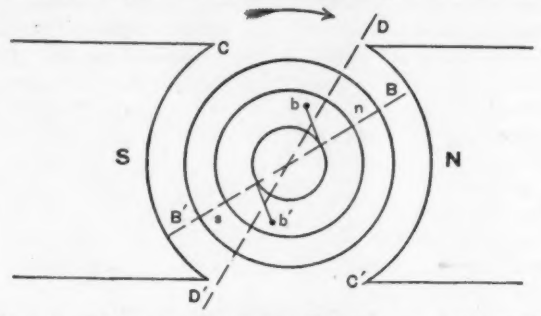


Fig. 4.—Diagram Showing Effect of Armature Reactions.

The characteristic of Fig. 2 illustrates a different design and a different state of facts. It was taken from a machine with a Gramme ring, built in Ann Arbor in the early spring of 1877, after designs of Prof. J. W. Langley. It has a capacity of fully 5,000 watts at a speed of 1,400 revolutions. So far as I have knowledge this was the largest dynamo machine built in this country at that date. Viewed from the standpoint of present knowledge and experience, it is faulty in design and of inferior workmanship; but when built, it embodied the latest facts known to the art.

It will be observed that at 10 ampères the field is not up to the saturation point, and the curve has not begun to bend over. Hence this machine serves to illustrate the quality of instability when run on 10-ampère arc lamps. The current runs with remarkable periodicity up to a maximum of about 12 ampères, depending upon the position of the brushes, and then down to zero, when the carbons all drop together and the field again builds up. It would run low-tension lamps successfully without doubt, though I have not had the opportunity of trying it. At 18 ampères the working part of the characteristic would lie well over the crown, where the field possesses greater stability. The lower curve is the external characteristic and the upper one that of potential differences at the brushes. The core of the armature of this machine consists of iron wire; the field magnet cores are composed of six flat plates of wrought iron, while the yoke and pole pieces are cast iron. The commutator has only 26 segments, but the sparking is slight.

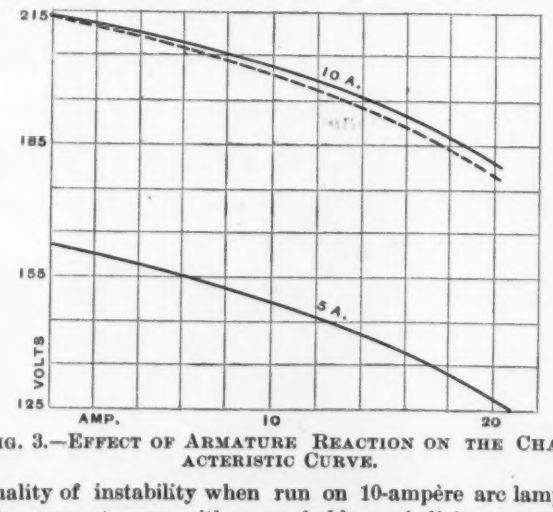


Fig. 3.—Effect of Armature Reaction on the Characteristic Curve.

To test the effect of the armature currents on the voltage the field was excited by a separate machine, first with five ampères and subsequently with 10. With a fixed position of the brushes the external resistance would gradually diminish, while the current taken from the armature increased. Now, if there were no reactionary influence of the armature, the curve connecting together ampères and total voltage generated by the machine, including the loss in the armature, should be a horizontal line. The actual curves for the two conditions of excitation of the field are given in Fig. 3; the lower was obtained with the five ampères in the field and the upper with 10. The actual drop in potential with the smaller excitation was 37.6 volts, and with the larger 33.4; but the percentage of depression in the two cases was 23 and 15.7 respectively. Thus, as anticipated, a relatively weak field shows the greater modification and distortion due to the armature currents. The difference in the two curves is shown by the superposition of the lower on the upper as a dotted line.

The nature of the armature reaction may be made out partly from theory and partly by means of appropriate experiments. So far as the direct influence on the field is concerned, it is referable to two quite distinct factors, which may be expressed in terms conformable to the modern method of analyzing a magnetic circuit. This consists in expressing the magnetic flux as the quotient of the magneto-motive (E. M. F.) force and the magnetic resistance. The currents circulating round the armature reduce the magnetic flux both by increasing the magnetic resistance or equivalent length of the magnetic surface and by generating a counter magneto-motive force. The former is affected in just that portion of the circuit where the resulting change is the greatest, that is, in the air interspace adjacent to the polar faces. The lengthening of the magnetic circuit in the vicinity of the polar margins *C*, *C*, Fig. 4, was well illustrated and suitably enforced by Mr. Dow in his paper before this club on April 6. The other factor appears to play a much more important part in regulation by motion of the brushes than the deformation of the field at the polar tips; for by means

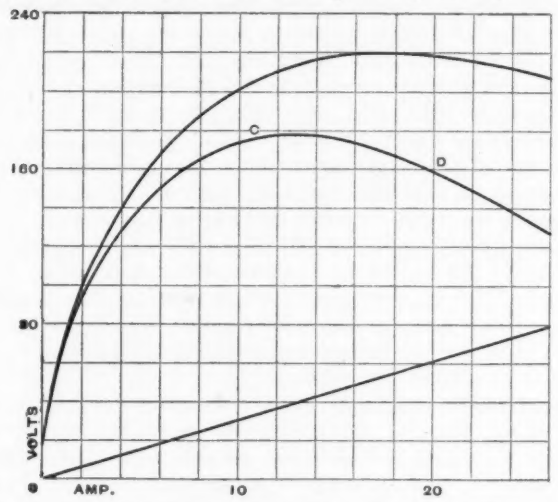


Fig. 2.—Characteristic Curve of a Gramme Machine Built in 1877.

of it the brushes may be kept nearly sparkless from full load to short circuit. That the magneto-motive force, having its origin in the ampère turns, on the armature is inverse and not direct, is evident from the fact that when the brushes are rocked forward the poles induced in the armature by the field, as at *B B′* in Fig. 4, are always of opposite sign to those produced by the armature currents. Hence these currents circulate in such a direction as to demagnetize the field. It is very difficult to estimate the relative value of these two factors of reaction, or perhaps the two phases under which this reaction may be studied, but it is not difficult to devise tests which demonstrate the relative difference of this reaction in the two classes of 24 fields before referred to. For this purpose a third brush, placed slightly in advance of one of the main brushes, serves a useful purpose.

Imagine the brushes placed on the line *B B′* in the figure, and the external resistance such that the normal current is flowing through the circuit; and let a voltmeter be connected with one main brush and the third brush, which makes contact with the commutator cylinder one or two sections in advance. If the current is increased by cutting off part of the load what may be expected to occur in the voltage of this supplementary circuit? Will it increase or decrease? That depends entirely upon the condition of the field as to separation. If the total E. M. F. of the generator remains constant, then, as with a battery, the increased current means increased loss of potential in the armature, and therefore a smaller difference of potential at the brushes; and if smaller at the main brushes it will be smaller between the points of derivation of the supplementary circuit. If the field is magnetized to that extent that it is only slightly sensitive to changes in the current, then an increased current will cut down the potential difference between the brushes, for the additional reason that while the influence of the field is not increased that of the armature is. With the field less highly excited, so that the permeability of the iron is not much reduced below its maximum, the dynamo responds to an increase of current with a denser field of force and a higher E. M. F. The growing current may then produce a greater effect in the field magnet than in the armature. In that case the potential difference both between the main brushes and in the third brush circuit will rise with the current.

Both these conclusions are verified by experiments on the machines, whose characteristics are given in Figs. 1

*A paper read before the Chicago Electric Club, May 25, 1891.

and 2. In the old Gramme ring machines, with current under 10 ampères and with the third brush two sections in advance of the main brush, an increase of current is accompanied by an increase of the voltage both between the two main brushes and in the third brush circuit as well. But with larger currents, approaching 20 ampères, cutting out resistance and increasing the current decreases both voltages. A point of excitation may be formed where no change in the third brush voltage follows a moderate increase or decrease of currents. With currents above 10 ampères the total voltage increases with the increasing excitation, while the potential difference between the main and third brush decreases. In the other machine the change is invariably an inverse one. I have tried it with small currents in the main circuit, since the field builds up very rapidly, as shown in Fig. 1.

That this decrease in the potential difference between the main and third brush is not entirely or largely due to increased loss of potential, consequent on the circulation of an enlarged current through the armature, is easily demonstrated by experiment. In fact, as already stated, it may be coincident with an increase of voltage at the brushes. A machine of the same type as Fig. 1 was run at varying loads, and the voltage in the accessory or third brush circuit was measured both when the current was increased by cutting out resistance and conversely. In every case an increase of current was accompanied by a decrease in the voltage both between the main brushes and the main and third brushes as well, while the diminished current was responded to by an increase in voltage in both places. Moreover, both the increase and the decrease were too large to be accounted for by loss due to resistance in the armature. I will select only two fair average examples out of many observations. Thus, current, 10 ampères; total voltage, 240.1; third brush, 15. Current increased to 11.41 ampères; total voltage, 211; third brush, 12. Now the resistance of the armature from brush to brush was 4.6 ohms hot, and the third brush was two segments in advance of the main brush. Total number of commutator bars, 72. Hence the resistance of the two sections of the armature to half the total current was 0.52 of an ohm. The loss of potential due to an increase of current from 10 to 11.41 ampères, or from 5 to 5.7 through either half of the ring, was 0.37 of a volt. But the total drop was 3 volts or 20 per cent. Again, with a current falling from 10 to 8.3, the voltage rose from 242.8 to 271.8, and the third brush voltage from 14 to 18. In this case the half current decreased 0.85 of an ampère. The gain in voltage in the third brush circuits alone should have been only 0.44 of a volt if this were the only reason for it. It was actually 4 volts. The imperfect contact of the third brush rendered exact readings difficult, but the variations were always much in excess of those calculated as above.

With this third brush set very close to the main one, so as to get a difference of about four or five volts between them on a 20-light machine, I have observed that the cutting out of a single lamp, whatever the total load might

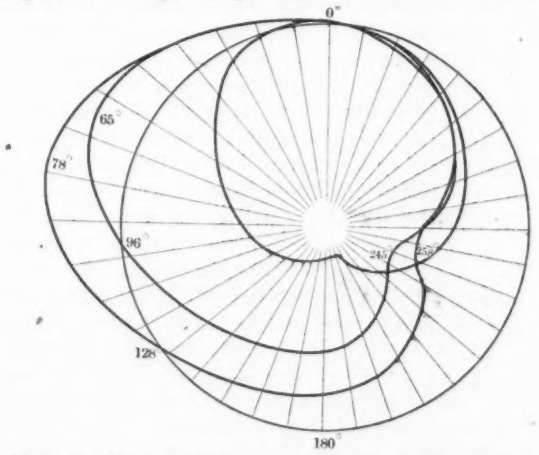


FIG. 5.—DISTRIBUTION OF POTENTIAL AROUND THE COMMUTATOR.

be, produced a reversal of the third brush current when this circuit contains relatively high resistance; and if the brushes are automatically moved by a regulator, which produces a gentle vibratory motion of the brush system back and forth, the third brush current will reverse with every backward oscillation of the brushes. The only interpretation of these facts which seemed to me at the time plausible was that the armature reaction was sufficient to cause the neutral line or neutral part of the field to follow the brushes quite closely in their motion about the commutator to maintain a normal current; and this explanation I gave to my class on dynamo machinery and maintained in a semi-public way. But further experiments, directed to the exploring of the commutator for the purpose of ascertaining the relative potentials of the various parts, have convinced me that this explanation is not the correct one.

The method consisted in attaching to the brush-holders a circular frame of insulating fibre, with slots cut every 10 degrees in its periphery by a milling machine, and employing these slots to hold in succession a third brush.

The potential difference between one of the main brushes and this movable third brush was measured entirely round the commutator with different loads and always with 10 ampères through the circuit of the machine. The first position of the brush was such that the potential difference was zero. The several values with no external load, with a resistance equivalent to three lamps, and finally equivalent to nine lamps, I have platted round the circle in Fig. 5; the position of the brushes 0 degree and 180 degrees. With the machine nearly short circuited and with the brushes rocked forward fully 65 degrees to 70 degrees beyond their position for maximum load, you will see that the potential ran up to a maximum positive at nearly 80 degrees from the positive brush, and then ran down, so as to be identical with that of the same brush at about 128 degrees. So also a negative maximum was attained at 260 degrees. The difference of potential between these two positive and negative maxima was 644 volts. The same difference was found when two extra brushes were placed at these two highest points. The line joining these points, usually called the theoretical neutral line, lies

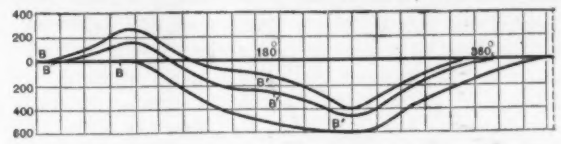


FIG. 7.—DISTRIBUTION OF POTENTIAL AROUND THE COMMUTATOR.

forward of the medial line between the magnet poles and is distant about 20 degrees from the leading pole tip. All the E. M. F. generated in the coils from 0 degree to nearly 80 degrees is therefore counter E. M. F. The same is true of the opposite of the armature. The points A A′ in Fig. 6 correspond to the two maxima described. At these points the E. M. F. generated changes sign and they must therefore be on the neutral line. *B B′* is the line of the brushes.

With three lamps in circuit, or their equivalent in iron wire resistance, the brushes were rotated backward 150 degrees, and the points of the highest and lowest potential, as compared with the main brush, were 65 and 245 degrees, being respectively about 168 and 456 volts. With the highest load carried, the brushes were rocked back 50 degrees further, and the two main brushes were then very nearly at the maximum and minimum points.

If now we study Fig. 5, we shall find that the region of the commutator on either side of a brush, or of the armature coils in these positions, is a relatively weak field, the angular distance through which the potential rises to a maximum being nearly double that required to bring it down again to the level of the main brush. Thus in the outer curve the maximum is at about 78 degrees, and it crosses the circle again at 128 degrees. So the next one attains its highest positive value in the vicinity of 65 degrees and crosses the zero level again at 95 degrees. Similar differences are exhibited on the opposite side of the circle of reference. In Fig. 6 the regions marked *W* are relatively weak, as compared with those marked *S*. The places of maximum activity are near the polar boundaries at *E*′. If the several maxima be laid off from the position of the brushes as zero, it will be found that they all fall as nearly as can be determined at the same place. This fact is brought out more clearly by plotting the potential differences as ordinates from a straight line as in Fig. 7. From these curves it is evident that the maximum positive and negative ordinates of the first curve, taken with no load, fall at about 78 degrees and 260 degrees respectively, corresponding in position as nearly as can be determined at the same parts of the field as those of the other curves. I find no evidence in these curves that the rocking forward of the brushes to control the current, with diminishing external resistance, causes the theoretical neutral line to move to any considerable extent.

I do find, however, that the poles of the armature, which are always at the brushes, exercise a marked influence on the field, wherever they are. It is easy to see that the curves are all flattened out in the vicinity of the brushes, as at *B′ B′ B′*. This flattened region extends a good deal beyond the limits of the contact of the brushes with the commutator cylinder, though the lapping over of the brushes doubtless contributes to this result. If we imagine a bar magnet placed in a powerful and approximately uniform field of force, or stream of lines of magnetic force, with its own field opposing that of the field in which it is placed, it is easy to foresee the effect it will have in reflecting and scattering the lines of the main field, so long as its own magnetism is not reversed—so long as it retains its own autonomy or system of governing forces within another system, which is the influence of the armature magnetism upon the field of the generator. It not only weakens that field by introducing a counter E. M. F., but it weakens the field locally by a deformation and scattering of the lines belonging to the field of the main magnet. Hence the flattening of the curves at the brushes, and the uniformity of field secured in their vicinity wherever they may be located.

Before leaving the curves of Figs. 5 and 7, it may be of interest to describe an additional experiment suggested by these curves. If two extra brushes are provided and made to bear on the commutator at the highest and lowest points of the curves in Fig. 5 or Fig. 7, then substantially the same current will flow through this auxiliary circuit whatever the load in the main circuit. To test this, two extra brushes were made to bear at points 80 degrees and 260 degrees distant from the main positive brush, with nothing in the main circuit except the electro-dynamometer. The conditions were those of the outer curve of Fig. 5. The circuit of the two extra brushes was then closed through a resistance of 180 ohms, and it was found that a current of 3.3 ampères was maintained through it. At the same time there was no increase of sparking at the main brushes, and the potential difference between them rose from 124 to 162 volts, the current increasing from 10 to 12.6 ampères. The same experiment was tried with the conditions necessary to secure the second curve, the extra brushes being fixed 60 degrees and 240 degrees, respectively, from the main brush. The current in the auxiliary circuit was three ampères, and that of the main current increased, but to a smaller extent than before. The contact of the small brushes with the commutator was not so good as it should have been.

The conditions requisite to maintain a sparkless commutator when the lead of the brushes is varied with a varying load, so as to maintain the normal working current, seem to me now quite clear. A fairly uniform field, with pole pieces not too heavy, and an armature magnetically powerful relative to the field, will accomplish the result when the field magnet is magnetized to such an extent that it is no longer greatly sensitive to moderate changes in the current.

The really fundamental condition is not the one generally or universally laid down in the books, viz., that the brushes shall be only slightly in advance of the theoretical neutral line, or the line across which the impressed E. M. F. in each coil changes sign in passing. The brushes may be at any distance from this neutral line. The condition is simply that the counter E. M. F. generated by any coil as it passes under the brush shall be sufficient to offset the E. M. F. of self-induction, due to a reversal of the current in a coil in passing from one side of the brush to the other, and shall in addition cause the newly directed current to grow to its normal value as the segment leaves the brush. This means that the field of force at the brushes shall be practically constant. This practical constancy is maintained in every well-constructed constant current generator, with closed coil armature, by the magnetic influence or reaction of the armature itself, in flattening out and weakening the field at its poles. No special proportioning is necessary to accomplish this result, since the old Langley machine, to which I have already alluded, shows the same property. It will govern from full load to no load without any marked sparking at the brushes in any position.

Individual machines of any type will have their own idiosyncrasies. The smaller patterns will sometimes spark more than the larger ones. Some will spark a little more at full load and some more at no load, and very many do not spark at all when the brushes are in good order and properly set. With all such machines the diameter of minimum sparking is practically the diameter of commutation for the constant normal current. The brushes cannot be placed near the theoretical neutral line, a little in advance of the needle points between the poles, *except at full load*, for otherwise destructive sparking will ensue. So also if

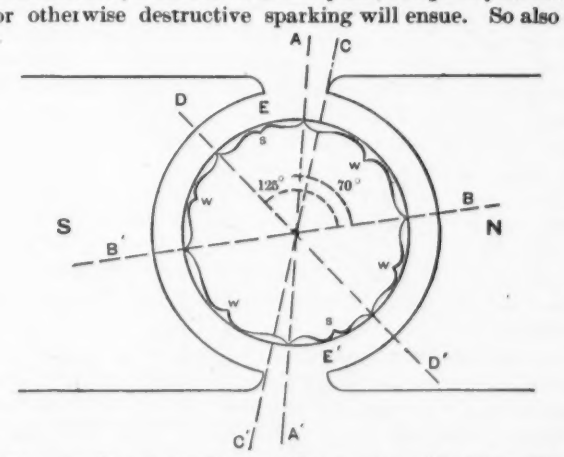


FIG. 6.—DISTRIBUTION OF POTENTIAL AROUND THE COMMUTATOR.

the field is separately excited, and the brushes are rocked forward on open circuit, furious sparking will take place. The coils are short-circuited then in an active part of the field, with no self-induction to overcome and no armature poles to plow through the field and deform it, scattering the lines of force as they move forward.

The change of voltage in the third brush circuit whenever the main current varies from its normal value suggests the practicability of utilizing this relation for the purpose of securing automatic regulation of the current. This method I have tried with satisfactory success. The third brush circuit contained an electromagnet as a responsive device, and this served to bring into action either an electromagnetic motor or mechanical motor mechanism for rotating the brush holder. With the third brush two segments in advance of the main brush, or about 75 degrees, the following table of results was obtained, as lamps were cut in and out.

Lamps.	Ampères.	Lamps.	Ampères.	Lamps.	Ampères.
16	10	7	10.2	3	10
15	9.9	6	10.1	5	10.1
14	10	5	10	7	10.5
13	10.2	4	9.9	9	10.5
12	10.3	3	9.6	11	10.3
11	10.4	2	9.8	13	10 2
10	10.3	1	9.3	14	10
9	10.2			16	10
8	10.2				

There was no sparking during the whole motion of the brushes. The practical constancy of current secured

demonstrates the constancy of the field in the vicinity of the brush when the main current is at its normal value. This uniformity near the polar surfaces of the armature, n whatever part of the field these poles may be, demonstrates that the armature reaction in constant current generators is of enormous importance.

If this third brush circuit is of such low resistance that the main current divides so that a material portion of perhaps 30 or 40 per cent. passes off through the third brush, then an increase of the total current through the armature is accompanied by an increased current from the third brush, since this current is merely a branch of the main current derived from the generator.

Test of the Power Plant of the Utica (N. Y.) Electrical Belt Line Railway.*

O. G. HEILMAN AND H. B. CLARKE.

This company operates 26 miles of road, there being three miles of double track on Genesee street. Twenty motor cars, and a number of "trailers," used when traffic is heavy, comprise the rolling stock of the system. A large, nearly fire-proof, depot is provided for the cars when they are not in use. This building also contains the offices of the company.

The power plant, a substantial brick structure, is situated outside the city limits, at a distance of about two miles from the business centre, and on the line of the D., L. & W. R. R. The steam part of the plant consists of three 200 h. p. Armington & Sims cross compound engines. Only two of the three engines are constantly in use during the day, the third being required only at intervals, when heavy loads are suddenly applied. Its use was not required at any time during the test.

The boiler room contains four horizontal tubular boilers, manufactured by Philo B. Curtis, Utica, N. Y. These boilers are each six feet diameter of shell, 16 feet long, and contain 88 three and one-half inch tubes. Two boilers only are used at a time, a change to the other set being made when cleaning or repairing is necessary. Two independent boiler feed pumps and one independent Davidson air and circulating pump with jet condenser are provided. A National feed water heater is placed between the boiler and feed supply, while a separator was placed on the main steam pipe, being furnished with a Curtis regulator to return the separated water to the boiler.

In the generation of electricity, six Thomson-Houston dynamos are in use, two being driven from each engine. The instruments used for measuring current and voltage are also made by the same company.

Two runs were made, a preliminary run on May 2 of five hours' duration, and the main test on the following day of ten hours, readings being taken from 9 a. m. until 7 p. m.

The feed water was measured by means of two calibrated barrels, one being filled while the other was emptying, and then reversing the process. Although the quantity of water required was large, by the use of this method no difficulty was experienced in keeping the supply equal to the demand. The injection water for the condenser was drawn from a pond near by, and after passing through the system was again returned to the pond through a sluice of rectangular section. The quantity of flow was obtained by placing a weir in the sluice, and the height of flow over the weir was measured by a hook gauge.

The weight of coal consumed was determined in the usual manner, a Fairbanks scale being placed in the boiler room, and loads of 200 pounds each were dumped in front of the boiler at a time. The ash pits were cleared at the end of the test, and the ashes placed in the barrow and weighed.

In order to obtain the quality of steam at the engines, a calorimeter was connected to the pipe leading to the oiling apparatus, the connection being made close to the engine throttle. A comparison of results taken from boiler calorimeter and engine calorimeter shows a wide difference in moisture in steam. Electrical readings of current and voltage were taken every five minutes during the test. Below are tabulated some of the more important results.

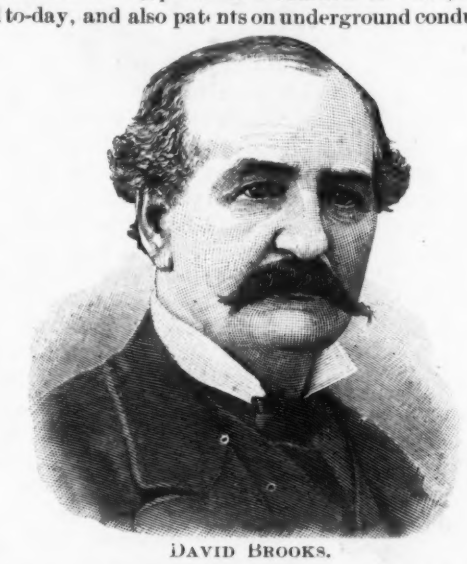
Character of draught	Natural
Temperature of external air	54.5 degrees Fahr.
Temperature of boiler-room	67.9 degrees
Duration of test	10 hours
Fuel burned	7,900 pounds
Total ash	988 "
Moisture in 100 pounds	8 "
Weight of combustible	5.452 "
Efficiency of combustion	82.15 per cent.
Kind of coal	One-third bit. slack and two-thirds anthracite culm
Fuel per square foot of grate per hour	11.6 pounds
Combustible per square foot grate per hour	9.087 "
Per cent. entrained water (boiler cal.)	1.24 per cent.
Total water supplied	49 355.4 pounds
Dry steam per hour from temperature feed water	4,875.1 "
" " " " " 212 degrees	5,414.22 "
" " " pound of coal	6.96 "
" " " square foot of grate	81.25 "
" " " " " heating surface	1.67 "
Thermal units per hour	given 7,905,400; received 5,793,978
Horse power (34.5 pounds water evap. per one horse power per hour)	143
Efficiency of boiler	73 29 per cent.
Average steam pressure (absolute)	133.8 pounds.
Temperature of feed water to heater	77.2 degrees.
" " " " from heater	161.5 degrees.
Change of temperature due to heater	87.3 degrees.
Revolutions of engine	261
Per cent. variation of speed	1.14 per cent.
Average indicated horse power	190.53
Quality of steam at engine	3.88 per cent. wt.
Coal per indicated horse power per hour	3.5 pounds.
Water per indicated horse power per hour (without charging condenser)	21.72 pounds.

$$\text{Average efficiency} = \frac{\text{Average electrical horse power}}{\text{Average indicator horse power}} = 81 \text{ per cent.}$$

*Abstract from the Cornell *Crank*.

Death of David Brooks.

On Sunday, May 31, David Brooks, one of the best known and oldest electricians in the country, died at his home in Philadelphia. Mr. Brooks was an old-timer, and had followed the development of the electrical arts from the very earliest days of the telegraph, so that few men were better known or more thoroughly appreciated in electrical circles. He was born in Brooksvale, Conn., Jan. 26, 1820, graduated from college at the age of 20, and became instructor of mathematics in the United States Navy. Five years later he left the service and took up the then new art of telegraphy. He was employed in the construction of telegraph lines in conjunction with James D. Read, and put into operation the first commercial line in America, that between Baltimore and Washington. A little later Mr. Brooks extended this pioneer line to Harrisburg, and received the first message ever sent over it, and then constructed the first line of the Atlantic & Ohio Company between Philadelphia and Pittsburgh. In 1851 he went to Mexico and introduced the telegraph into that country, building the first line there between Vera Cruz and the City of Mexico. He was then appointed manager of the Philadelphia & Pittsburgh line of the Pennsylvania railroad, and in 1854 was made superintendent and manager of the Atlantic & Ohio Telegraph Company. In 1862 this organization was absorbed by the Western Union, and Mr. Brooks was appointed district superintendent at Philadelphia, which position he held for five years, when he resigned and occupied himself with the development of various electrical inventions. Mr. Brooks was a prolific inventor, especially in the department of telegraphy. Among other patents were those covering paraffine insulation of wires, so largely used to-day, and also patents on underground conduits with



DAVID BROOKS.

oil insulation, which have proved very useful for certain purposes, and have been introduced in England and in this country. It was in this line of work that Mr. Brooks was engaged at the time of his death. As one of the pioneers in telegraphy, and an enthusiastic student of every important electrical problem, Mr. Brooks had become very widely known, and leaves a host of friends.

Death of Edward H. Goff.

Edwards H. Goff, who a few years ago was one of the most prominent and one of the most aggressive and enterprising men in the electrical business, and who in those comparatively early days probably did as much as any single individual to introduce and popularize electric lighting, died last week, in this city, of Bright's disease. Although he was somewhat idiosyncratic and perhaps a little unorthodox in business matters, and although some of his ideas seemed wild and visionary to conservative investors, those who knew Mr. Goff best had confidence in his personal honesty. Mr. Goff had many charming qualities of manner which made him hosts of warm personal friends. His acquaintance among well-known men was very large, and he had the reputation of being a brilliant financier and business man, and of being able to raise more money on enterprises with less tangible assets than any man in the country. He lived in an atmosphere of millions, was princely in his ambitions and his extravagances, and strikingly able and original in his schemes for making money. If, in addition, he had possessed in the same degree the qualities of a good practical business man, or if he had permitted his actions to be influenced or controlled by one who had such qualities, he might have died very wealthy. As it is, his sudden death leaves his family almost penniless and the company of which he was the head in a hopeless condition. It has been rumored since his decease that he had just succeeded in negotiating a most lucrative private treaty with the South American Republic of Ecuador by which all the trade between the United States and Ecuador was to pay tribute to him, but this is denied over the signature of Consul-General Ruiz, of Ecuador. It was also said that similar private treaties even more profitable were under way with other governments below the equator, and that the Ecuador officials had even advanced Goff $40,000, which reached the office the second day after his death. Many, however, are inclined to doubt these statements.

The Future of the Aluminium Problem from the Chemical Standpoint.*

BY DR. WM. H. WAHL.

I propose to invite your attention in the following remarks to the consideration of the possibility of cheapening the cost of producing aluminium by improvements in chemical processes.

It is obvious at the outset that the selection of the aluminous compound to serve for reduction is of the highest importance. The compounds available for the purpose are three in number:

1. The halogen compounds (chloride, fluoride, etc.).
2. The sulphide.
3. The oxide.

Thus far the compounds first named have been the only ones that have yielded satisfactory results on the commercial scale, and it would seem probable that if a substantial advance in the metallurgy of aluminium may reasonably be expected, it should be looked for in connection with those compounds that have heretofore proved to be the most pliable in the chemist's hands. It will be most instructive, therefore, to examine the processes based on the use of the halogen compounds of aluminium and to endeavor to ascertain to what extent the economies already realized in practice bar the way to further improvement.

These processes which held the field alone until driven from it by the remarkable development of the electrical methods are based upon the reduction of the chloride or fluoride of aluminium by means of sodium. For practical purposes it is found preferable to employ, in place of the simple chloride or fluoride of aluminium, the corresponding double salt of sodium.

First in order, let us consider the Deville-Castner process. This embraces three operations—the manufacture of the double chloride of sodium and aluminium, the manufacture of sodium, and the reduction of the double chloride by sodium.

The statement will not be questioned by chemists that the use of the chloride as the aluminous compound to be reduced is attended with difficulties. It cannot be produced in the wet way either by precipitation or by the evaporation of its aqueous solution, and a roundabout furnace process is the only method by which it has thus far been produced commercially. Furthermore, it is so readily decomposed that it must carefully be preserved from the access of moisture. Also, though its reaction with sodium takes place with great energy, it has been found practically impossible to obtain by its use more than about 75 to 80 per cent. of the contained aluminium for physical reasons inseparable from the conditions under which the reaction occurs.

Its advantages are, its ready fusibility, in consequence of which the reaction with sodium begins at a comparatively low temperature, and the fact that it may be obtained entirely free from silicon and almost free from iron, the two elements that exert the most deleterious influence upon aluminium.

It is a just tribute to the skill and ingenuity displayed by the able chemists in charge of the Deville-Castner plant, at Birmingham, to give them credit for having succeeded in reducing the cost of sodium-aluminium chloride from about 22½ cents (which is believed to be a fair estimate of its cost before the improvements of Webster and Castner) to about 6 cents per pound. You will doubtless have heard much of the claims of several processes for the direct production of the chloride, by passing gaseous mixtures containing chlorine and carbon over heated alumina contained in retorts suitably connected with a condenser. By one of these described in Richards' admirable treatise on aluminium the cost of production is affirmed to be as low as 1¼ cents per pound. By another process which is exceedingly plausible, hydrochloric acid vapors are passed into an electric furnace, in which aluminium is being decomposed by carbon, the chloride formed being condensed in a suitably connected chamber.

Either of these plans, so far as one may form a judgment from their general features, appears to possess decided advantages over the older one employed in the Deville-Castner operations. Thus far, however, none of them, so far as I am aware, have been put in practice on a commercial scale, and, promising as they appear to be, I incline to the belief that the fluorides present such advantages that if there shall prove to be any future for aluminium processes based on the use of sodium as the reducing agent, the fluoride compounds of aluminium, and not the chlorides, will be used for the purpose.

The reasons for this opinion are: The fluorides are absolutely staple at common temperatures; they may be highly heated without suffering notable loss by volatilization, and, by employing proper precautions in bringing the reducing agent in contact with them, they can be made to yield very nearly the theoretical quantity of contained aluminium in condition to be at once and without further manipulation cast into ingots.

Respecting the comparative cost of the chloride and fluoride of aluminium, while reliable data are wanting, I am confident that the opinion of chemists who have given the subject any consideration will incline in favor of the fluoride. There is this important advantage in its favor, that the resulting product from the reaction of sodium with

* A paper read before the American Institute of Electrical Engineers, May 21.

aluminium fluoride, *i. e.*, sodium fluoride, by very simple and inexpensive operations may be made to yield, on the one hand, sodium hydrate, which may be utilized for the production of sodium, and on the other hand, aluminium fluoride, thus regaining, at comparatively little cost, both the reducing agent and the aluminium compound to be reduced.

In the case of the chloride the end product of the reaction is sodium chloride, a substance of such little value as to be hardly worth the cost of evaporation and utilization. For these reasons, in the consideration of the future possibilities of the sodium process of producing aluminium, I believe the use of the chloride may safely be assumed to be impracticable.

We come now to the consideration of the remaining element of the chloride and fluoride reduction processes, namely, the question of the sodium. I am aware that the weight of opinion among chemists who have given the subject very careful consideration is unfavorable to the future prospects of aluminium processes in which sodium is relied upon as the reducing agent. Richards, for example, whose opinions on all questions pertaining to the aluminium problem are entitled to the highest respect, in a lecture on this subject lately delivered before the Franklin Institute, says on this point: "I do not consider the sodium processes, however, as ever likely to take part again in the metallurgy of aluminium. I think their day is past."*

I will not venture to dispute the correctness of the conclusion to which this very able and conservative author has arrived, since there are other metallurgical methods that appear to be much more promising. The author I have just quoted indeed appears to be of this opinion, inasmuch as he says in the same paragraph, ". . . although electrical processes are 'on top' at present, and, I think, will stay there for some time to come, I am far from considering that they may not possibly be superseded by non-electric methods of reduction."

It may be true that the sodium processes have had their day in the metallurgy of aluminium, but I am confident that the prospects for much cheaper sodium in the near future are decidedly brighter than those for cheaper aluminium. Without underestimating the great difficulties involved in the production of sodium, and duly appreciating the value of the services of Deville, Castner, Netto, and others who have contributed meritoriously to the problem of reducing the cost of its manufacture, I have been impressed of late with the belief that all the methods hitherto proposed and employed for the production of sodium are extremely crude in conception and imperfect in practice. For one, I think it would be entirely possible very greatly to reduce the cost of making sodium by the metallurgical way, but, to do so, it must be manifest to all who are familiar with the past and present methods of manufacture that these will have to give place to others operated on some radically different plan.

My reasons for this opinion are briefly these: The cost of a metallurgical operation is largely affected by the scale of magnitude on which it is conducted; and, where heat is required to bring about the needful reactions, by the economy with which it is applied to effect the result, and, if it be a furnace process, whether the operation is continuous or intermittent.

The capacity for production of a metallurgical plant increases in a much greater ratio than the item of labor cost; so that in such cases the doubling or quadrupling of the output may be accomplished with a correspondingly enlarged plant, with the aid of comparatively little additional labor.

Where heat is the prime element in reducing the reactions—which is practically always the case—those who have experience with steam power plants need not to be told how seriously the economies of a mill or factory are affected by the choice and proper installation of boilers and engines. In metallurgical operations the limits between economy and wastefulness in the application of fuel are much further apart. The question of economy, also, is materially affected by the manner in which the process is operated, *i. e.*, whether continuously or intermittently. A continuous furnace process, of which the blast furnace for producing iron affords us a typical example, realizes the highest attainable economy, and wherever it may be found practicable to adopt this feature of operation, the cost of the output will be notably reduced over processes worked at intervals.

Examining the sodium processes by the light of the foregoing statements, it will appear that none of them fully realizes the conditions essential to the highest economy of operation. A few words of a critical nature upon the methods of Castner and Netto, which may stand for the most advanced sodium processes, will enable me, I think, to make it clear, in spite of the decided advance over previous methods which they exhibit, that from the metallurgical point of view they are very imperfect.

Castner, for example, operates on a number of small charges, introduced into a group of steel crucibles about 18 inches wide and 24 inches high, and capable of receiving a charge of 15 pounds of caustic soda and a suitable quantity of the reducing agent. The arrangements for removing a crucible from the furnace after its charge has been delivered, clearing it of the residuum, recharging and returning it to the furnace, permit these operations to be effected in about two minutes, so that the vessel still retains a good red heat when restored to its place for a second operation. The crucibles are heated by producer-gas.

The theoretical yield of a single charge of the above-named quantity should be 8.62 pounds; the actual yield in current practice at the Oldbury works, near Birmingham, according to Mr. J. MacTear, who has reported the results of a very thorough examination of the process, is 2.5 pounds, or 29 per cent. A much larger yield, approximating to the theoretical quantity has been obtained, but this cannot be realized in practice, because the extremely high temperature demanded for it would result in the rapid destruction of the crucibles.

The great advantage of Mr. Castner's process over older methods lies in the fact that by the employment of a special reducing agent (an intimate mechanical mixture of coke and carbide of iron) he is enabled to operate upon caustic soda, which may be reduced by carbon at a much lower temperature than the carbonate. The inventor has claimed that by this process the cost of manufacturing sodium on a large scale will not exceed 25 cents per pound. Mr. MacTear has named the result of his experimental work at the Oldbury establishment 16½ cents (eight and a quarter pence).

I have no data at hand from which to determine how nearly either of these estimates is actually realized in current practice. I can only say that the price at which the product of the works is quoted on the market will yield the manufacturers 200 per cent. profit on the price named by the inventor.

Dr. Netto's process, in the opinion of competent judges, is the most economical method that has yet been put in practice; nevertheless, like that of Castner, it fails to realize, save in one important feature, the conditions of highest economy that I have assumed to be essential in a metallurgical operation.

In order that the bearing of this criticism may appear, it will be well to present a brief description of the process for the information of those who may not be familiar with it.

Dr. Netto uses a cast-iron retort, about three feet high and two feet in largest diameter, lined exteriorly with fireclay, and placed vertically in a furnace in which it can be heated to the desired temperature. The flames of the furnace, after passing around the retort, may be directed laterally so as to pass beneath an iron pot supported above the retort and to one side of it.

This pot is supplied with caustic soda, kept in a state of fusion by the waste heat of the furnace, and provision is made for feeding the soda in a regulable stream into the retort at the proper time. In connection with the retort there is a condenser for the sodium, and also a trapped pipe at the bottom through which the accumulated carbonate may be allowed to pass out of the retort.

The retort is charged at starting with 50 kilos (110 pounds) of charcoal or coke, and when this has been brought to bright incandescence, the valve controlling the access of the soda is opened and the fused alkali is permitted to flow into the retort and upon the glowing carbon. The reaction begins at once, and the sodium, distilling over, is caught in the condensing chamber.

The feed of the alkali is controlled by an attendant, who judges of the quantity to be admitted by the appearance of the flame of the gases, which burn at the outer orifice of the condenser. The process goes on continuously until the charge of carbon in the retort is nearly spent, the heat abstracted from it as the reaction proceeds being restored by the heat supplied to the exterior of the retort from the furnace, which is kept constantly fired.

When the carbon in the retort shows signs of exhaustion the flow of soda is checked, the retort is charged afresh with charcoal, and when this has been brought up to the right heat the operations just described are repeated.

In Netto's process, as in Castner's, it is found necessary, in order to avoid the rapid destruction of the retorts, to maintain the temperature of the retort and contents only slightly above that required for the decomposition of sodium hydrate by carbon, which requires only a full red heat to deliver sodium freely, and has the economic advantage of permitting the use of crucibles or retorts of cast iron. The reaction of sodium hydrate, however, as I have already intimated in the consideration of Castner's process, is not complete, but, according to the heat of the charge, and to some extent, perhaps, by the manner in which the component parts of the charge are brought into contact, a varying proportion of the hydrate is always converted into carbonate, which can only be decomposed at a temperature approximating that of white heat.

In Castner's process the yield of soda, as we learned, is about 30 per cent. of the theoretical; in Netto's it amounts, according to the most reliable data I have at hand, only to 20 per cent. It appears, therefore, that 80 per cent. of the sodium charged into the retort in the form of caustic soda is converted into carbonate. This carbonate, after the operation of the retort is once established, is permitted to discharge itself automatically through a siphon, provided at the bottom, and, after re-conversion into caustic by treatment with lime, is ready to serve for another operation.

The advantage of Netto's process, as compared with Castner's, lies in the fact that the former is continuous—at least approximately so—a feature which permits of a large saving in the cost of labor for the same amount of output, since it dispenses with the frequent withdrawal, cleaning out, recharging and returning of crucibles to the furnace, incidental to the latter; furthermore, the conditions under which the Netto process is operated are, other things being equal, more favorable to the economical use of the fuel. Nevertheless, so thoroughly is every detail of the Castner process carried into practice that the cost of production by the two processes is probably almost the same. I have no possible information as to the actual cost of sodium by Netto's process, but, if the selling price may be considered as a reliable indication, the opinion just expressed is substantially correct.

It may be unwarranted, in the face of what has already been accomplished in this branch of the chemical industry, to anticipate still further and greater advances in the direction of diminished cost of production, but the recent history of aluminium should prove a warning to him who may be inclined to play the role of Sir Oracle; and this warning applies, in my judgment, with special force to the sodium problem, as I will endeavor to show.

As comparison is the most instructive form of illustration, I will ask your attention to the following parallel, by which I wish to exhibit how very wasteful the present representative processes for sodium appear; and, also by comparison with other metallurgical processes, how far we should be able to improve upon them by the intelligent application of well-known principles; to wit:

Starting from the reaction which most clearly represents what takes place in the retorts of Castner and Netto, namely:

$$3\,NaOH + C = Na_2CO_3 + 3\,H + Na,$$

and, assuming that the partial conversion into carbonate of the sodium contained in the caustic and the liberation of only one-third of the metal at one operation, affords practical advantages on account of the moderate temperature at which the reactions take place, the following conclusions may be stated:

The molecular weight of the 4 NaOH in the preceding formula is 120; that of the carbon 12 (or 10 to 1). Assuming that the heat necessary to cause the foregoing reactions to take place has been supplied, one pound of carbon interacting with 10 pounds of caustic soda (containing 5.75 pounds metallic sodium) should yield

1.92 pounds sodium metal and
3.83 pounds sodium in the form of carbonate.

(The value of this carbonate should properly be credited by deducting it, less the cost of re-converting into caustic, from the cost of raw material. This credit will appear later.)

As that portion of the reaction which results in the production of the carbonate is exothermic (*i. e*, one which liberates heat), its influence on the question of the heat involved may be ignored.

One pound of carbon at the temperature of reduction yields in round numbers two pounds of sodium. To this must be added the carbon necessary to heat the retort and its contents to the reduction temperature, and to maintain it at that temperature while the reaction is taking place. The conditions of practice are so complex as to render any theoretical estimate of this factor of no value. We shall be quite safe, however, in accepting as a guide the figures actually obtained in practice, in the reduction of another oxide with carbon, *i. e.*, the oxide of iron, the data concerning which have been so carefully observed that we can hardly go astray.

In modern blast furnace practice one pound of carbon suffices for the reduction of one pound of iron. The reactions in the iron furnace may be explained by assuming, first, the formation of carbonic oxide by the union of the carbon with the oxygen of the blast, thus:

$$3\,C + 3\,O = 3\,CO;$$

And the formation of metallic iron by the interaction of this carbonic oxide with the ore, thus:

$$Fe_2O_3 + 3\,Co = Fe_2 + 3\,CO_2.$$

Whether this expresses correctly the course of the reactions within the blast furnace, or, whether the reduction of the oxide of iron is effected directly by the carbon is a matter of indifference for the purpose of my illustration, since the final result, *i. e.*, the reduction of a metallic oxide by carbon with the aid of artificial heat, is the same in the case of both iron and sodium.

Now, proceeding with the iron reaction, as I have previously done with sodium, theory requires that 36 pounds of carbon at a certain heat shall reduce 160 pounds of ferric oxide, yielding 112 pounds of metallic iron. One pound of carbon should therefore yield, say three pounds of iron. Now, one pound of carbon, it will be remembered, actually suffices for the reduction of one pound of metallic iron, or approximately one-third of the amount of metallic iron which theory demands.

It follows, therefore, that for every pound of carbon usefully consumed in the reduction process two pounds of carbon are consumed in heating the charge or the furnace to the temperature at which the reaction between the residual carbon and the ferric oxide will take place.

The comparison between the economy realized in the production respectively of iron and sodium may now be instituted with instructive results.

As previously pointed out, theory demands that one pound of carbon at the temperature of reduction shall yield from caustic soda two pounds of sodium.

* Richards: "The Aluminium Problem," *Jour. Frank. Inst.*, March, 1891.

From the figures of fuel consumption in the published accounts of Castner's and Netto's processes, I have been able to make the following estimate, viz.:

Castner obtains one pound of sodium with a consumption of 14 pounds of fuel.

Netto obtains one pound of sodium with a consumption of 11.6 pounds of fuel.

Averaging these results, it will appear that one pound of carbon yields in practice approximately one-twelfth of a pound of sodium, where theory demands two pounds. The conclusion is at hand, therefore, that of the 12 pounds of carbon required for one pound of sodium $\frac{23}{24}$ (or 11.5 pounds) are consumed in the work of heating and maintaining the retort and its contents at the temperature of reduction.

The iron furnace, as previously calculated, requires but two pounds of fuel for this work, therefore the latter is approximately six times as economical in respect of heat utilized as the sodium furnace.

This comparison, I believe, is a fair one, and the conclusion is justified therefrom that, by the application of heat with the same economy that is realized in blast furnace practice, the cost of sodium could be reduced to about one-fourth of the present figures.

Taking MacTear's estimate of the cost of the Castner process, namely, 8½ d. (16½ cents), and allowing 2½ cents per pound as a standing charge for the caustic, the fuel saving indicated above would bring the cost of the metal to the very low figure of 5½ cents per pound.

Assuming, now, that we operate on an aluminous fluoride with the cheap sodium just obtained, the final products will be aluminium metal and sodium fluoride. From the latter product, by a process like that of Herr Grabau, of Hanover, or by several other available processes analogous to it in general features, the aluminous fluoride almost chemically pure may readily be regenerated, thus offering the material for the continued operation of the reducing process, and at a cost, I feel assured, that will compare favorably with that of anhydrous alumina prepared from beauxite, which is the source of the aluminium manufactured by the electrolytic methods of Hall, Minet and Herault.

Furthermore, a simple series of reactions could readily be made available by which, not only the fluoride would be regenerated in the form of aluminous fluoride, but the sodium also would be recovered in the form of caustic soda, which last would furnish the raw material for the production of more sodium.

Allowing for the unavoidable losses in operations of this kind conducted on a large scale, it is not an extravagant estimate to assume that 75 per cent. of the sodium could thus be recovered after it had served the purpose of reacting on aluminium fluoride.

The regeneration of the sodium by some such method as I have here outlined, I need scarcely add, would mean another notable reduction in the cost of sodium metal, since it would mean supplying a large proportion of the raw material needful in its manufacture at less than one-half of its market price.

As caustic soda represents very nearly 50 per cent. of the cost of manufacturing sodium by present methods, the effect of such a saving as this would be to reduce still further the cost of the sodium operation. Assuming that this item of saving represents one-fourth of the cost of manufacture, the figure previously named (5 cents) would be reduced to 3¾ cents.

The realization of these economic conditions on the industrial scale, of the feasibility of which I feel assured, would place the metallurgical methods again in a position to compete advantageously with the electric.

On the basis of these facts and inferences let me present you with an interesting comparison.

Capt. Alfred E. Hunt, in a lecture recently delivered before the Boston Society of Arts, gave an estimate of the probable cost of manufacturing aluminium by the electrolytic method practiced by the Pittsburgh Reduction Company, of which he is the head. This estimate is based on the assumption that the manufacture shall be conducted on a scale of much greater magnitude than at present, and with the cheapest source of power, namely, water power.

Apropos to this estimate of Capt. Hunt, I wish to remark that it has afforded me a most interesting subject for study, and I desire here to declare my conviction that it is in no single item exaggerated on the side of economy. Respecting one of the figures named—that of the cost of water power—I entertained at first some doubts as to its accuracy, and to satisfy myself on the point I presented the inquiry to my friend, Prof. Coleman Sellers, an engineer of wide experience, and at present one of the board of consulting engineers to the Cataract Construction Company, which is engaged in the important work of utilizing on a grand scale the water power of Niagara Falls.

I take the liberty of quoting to you from a letter which I received from him some data covering the subject of my question:

"Almost all the existing examples of water power are dependent upon accumulation of water in reservoirs created by erecting dams across existing rivers and so accumulating water and distributing it by canal to the water wheels, as at Holyoke, Lawrence and our own Schuylkill River. The water power, for instance, of the Schuylkill and sold by the Schuylkill Navigation Company, was quite limited in its amount and is already exhausted, and it may be assumed to be somewhere in the neighborhood of $30 or $35 per horse power per annum, for day use only.

"These water powers are generally sold either by day use or by 24-hour use, and for the purpose of metallurgical reductions it would probably be required on the 24-hour basis.

"The difficulty about getting at the cost of these water powers is the uncertainty of the continuance of the dams that are built to retain the water. These are liable to decay and deterioration, and sudden freshets often destroy them entirely, involving heavy costs that are not known until the event occurs. The exceptional case of Niagara presents an absolutely unfailing water power that does not vary the year round. The difficulty in the way of its use, however, consists in the extreme width of the breast of the dam and the necessity for carrying the water through a long surface canal to the lower chasm where it is to be used, or the digging of the tunnel as a tail-race to carry away the water that has been used from the wheels or other motors.

"A canal was built about 40 years ago which is still in use, that carries about 6,000 h. p. to the lower river, but this amount of power has already been more than exhausted by users who availed themselves of it, and its further extension by that method would be very costly.

"The present scheme of utilizing Niagara Falls by the company in which I am interested, is by means of a tail-race tunnel under the town of Niagara, and the preliminary work now being done, when completed, in about a year, will throw into the market about 120,000 h. p. that may be said to be absolutely permanent and endurable, and capable of being worked for 24 hours in the day.

"It is premature to say what this power will bring in the market, but it is the only example I know of where water power can be counted on as absolutely stable and not liable to any disturbance or delay, and where the price will be comparatively low.

"I should think that you might safely say that it presents the possibility of power being obtained at less than half of what it would cost in any other known case, taking into consideration all contingencies. Small amounts of power may be obtained from streams of water of a reasonable degree of stability and far away from existing markets as low probably as $4 or $5 per horse power per annum, but this is subject to the risk before mentioned.

"It is not alone the mere cost of water power that must be considered, but in a case like this it is the continuance or permanency of the power that will give its value, and that power will be the most valuable that is liable to the least fluctuation either in quantity or cost.

"I do not think, however, that it will be safe for you to predicate the value of metal produced upon anything short of about $15 per horse power per annum, for 24-hour power, and that in very large quantities, while perhaps $20 per horse power per annum would cover all contingencies."

Taking the estimate of $20 per horse power per annum as sufficient "to cover all contingencies," we would have as the cost of one horse power per hour 0.238 cents (or say about one-fourth of a cent).

This would give for 22 h. p. 5¼ cents, and for 22 electrical h. p., allowing 10 per cent. for loss in the conversion, 6 cents. Capt. Hunt allows 5 cents for his power, which, considering that the figure named by Prof. Sellers is obviously intended to be liberal, I feel satisfied is a fair one. This item of Capt. Hunt's estimate is the only one respecting which I have at any time entertained any doubts, and I have been so impressed in reading his admirable lecture with the carefulness and accuracy of his statements and his evident desire to avoid any suspicion of exaggeration, that I am quite prepared to accept the other figures, which are based on the experience gained in the practical working of his company's plant.

Resuming the thread of my discourse after this slight digression, I beg your attention to the comparison to which I alluded. Capt. Hunt's estimate of the capabilities of the electrolytic method of producing aluminium on the largest scale is as follows:

BY THE ELECTROLYTIC METHOD.

Cost of Producing One Pound of Aluminium.

2 pounds alumina (contains 52.94 per cent. Al_2), at 3 cents ...	$0.06
1 pound carbon electrodes, at 2 cents	.02
Chemicals, carbon dust and pots.....	.01
22 e. h. p. for one hour (water power).....	.05
Labor and superintendence.....	.03
General expense, interest and repairs.....	.03
	$0.20

In presenting by way of comparison the possible figures of a metallurgical method, conducted on the same extensive scale and on the lines of my previous comments and explanations, I will assume that the cost of the last two items of the foregoing estimate will be the same, an assumption which may be made with safety.

Referring now to the preceding data, we will have

BY THE METALLURGICAL METHOD.

Cost of Producing One Pound of Aluminium.

3¼ pounds Al_2F_6 (containing 32.7 per cent. Al_2), at 3 cents...	$0.09¾
2⅛ pounds sodium, at 3¾ cents.....	.09⅜
Labor, superintendence.....	.03
General expenses, interest and repairs.....	.03
Total.....	$0.25⅛

I think that I have presented in the foregoing the capabilities of the sodium process within entirely reasonable bounds. I admit, however, that I have made the best possible showing for the metallurgical side, except in respect of the last two items, in connection with which metallurgical operations should show an appreciable advantage over the electrolytic and may bring the totals of the two estimates practically to an equality.

The second available compound named as a possible source of aluminium by chemical methods is the sulphide, including therein, of course, the double sulphide with sodium or other alkaline metal. I refer to it only because of the fact that its use for the purpose was originally suggested by one of the ablest chemical engineers of our day, the late Mr. Walter Weldon. Thus far, however, nothing has been accomplished with it, and, though it may be possibly made to serve to advantage in electrolytic methods, I am satisfied that the probabilities are very slight indeed that it will ever prove sufficiently useful as a source of aluminium to be able to compete with other chemical methods.

Not only is its manufacture attended with unusual difficulties, but its reduction also, so far as I am able to judge from personal experience, cannot be effected as readily as that of the chlorides and fluorides, and the resulting product is much less pure than that obtained from the other aluminous compounds just named.

The sulphide, I believe, is much better adapted for the production of aluminium alloys than for aluminium, but the difficulty of obtaining the product free from serious contamination is probably the reason why the sulphide method has never made a record for itself.

I consider the case of the sulphide from the metallurgical point of view to be so impracticable as to be hopeless.

The third aluminium compound which the chemist may hope to make available as a source of cheaper aluminium is the oxide. Considering the subject from the chemical standpoint, I am persuaded that the attack upon the problem, with this compound as a starting point, offers even greater possibilities of ultimate success than the sodium and fluoride method we have just passed over, and for the reasons that it involves the possible application of the cheapest of all reducing agents—carbon—in the production of the metal, and the employment of much more direct methods and simpler and less expensive apparatus than is demanded by the method with sodium.

The fundamental fact that alumina can be reduced to the metallic state by carbon is established. It is proved beyond peradventure by the operation of the electric furnace of the Cowles Bros., in which heat, developed by the transformation of electric energy upon the passage of the electric current through a fragmental resistance material of carbon and alumina (with copper or other metal present as a solvent), is believed to be the principal agency in effecting the reduction. The same action may probably take place, to some extent, in the operation of the Herault furnace, and certainly does so, if the statement can be verified that the output of this furnace is greater than can be accounted for by simple electrolytic action.

The reduction of alumina by carbon, therefore, may safely be stated to be simply a problem of temperature, and this temperature is probably not far above the fusion point of alumina. This, unfortunately for the practicability of the direct reduction process, lies enormously high, so high, indeed, that it does not admit of instrumental measurement, but can only be approximately estimated as somewhere between 2,000 degrees and 2,600 degrees C., a point which cannot be reached save by the intervention of electric heating.

There is an alternative, however, that offers a ray of hope to the chemist. There are other methods besides that of fusion for obtaining alumina in the state of a liquid. We have, at least there are very good reasons to believe that we have, solvents for alumina, and if the condition of fluidity is as important a factor as it is believed to be in inducing chemical reactions, we have the possibility open to us of establishing conditions favorable to the reduction of alumina by carbon at temperatures perhaps far below the fusion point of alumina.

The fluorides of the alkalies and the alkaline earths, we have reason to believe, dissolve alumina freely, and there are other compounds into which alumina enters that may be dissolved in the proper menstrua.

Here is the vulnerable spot in the armor with which that intractable substance is surrounded, and by concentrating his attack upon it the chemist may yet succeed in piercing it. Whether by this mode of attack he will be able to produce aluminium directly is gravely doubtful in the light of our present experience. I can only affirm my belief that the thing is within the range of possibility. On another point, however, I can speak more confidently, namely, as to the practicability of producing the alloys of aluminium by some such method. Of this I have not the slightest doubt. I will go even farther, and venture a prediction that in the near future the alloys of aluminium will be produced at least as cheaply by chemical methods as by the present electrical methods.

I have now passed over the ground, though hastily, that I had mapped out for my discourse upon this most fascinating technological problem. I have thought that by presenting the aspects of the problem from the chemist's standpoint the subject could be made more interesting to a representative body of electricians, such as the one I have the honor of addressing.

Briefly summarized the case stands thus:

The processes in which electricity is applied, either for the direct reduction of aluminium by electrolysis or as the

agency for producing the heat required to effect its reduction by chemical reactions, have outstripped the metallurgical methods in the race for supremacy and have taken a decided lead.

Within the past two years the metallurgical processes as represented by the improved methods of Castner, Netto, Grabau, and others of less renown, have been forced to abandon the field to the electrical methods of Hall, Minet, Cowles and Herault.

In one brief lustrum to have overtaken and gained the mastery—though it should prove to be but temporary—over a champion so redoubtable as the chemist, who has been striving for the glittering prize through half a century of toilsome progress and indifferent success, is an achievement of which the electrician may well be proud. It behooves him, though, to look well to his freshly earned laurels, for his victory will stimulate his rival to renewed exertions.

But let our sympathies incline this side or that, if the outcome shall be—and I am persuaded it will speedily be—the final solution of the aluminium problem, we may rejoice in common, for in the victories of peace the vanquished share with the victors in the spoils of the battle.

I thank you, Mr. President and gentlemen of the Institute, for your patient attention.

A Photographic Study of the Electric Arc.*

Prof. ELIHU THOMSON: I would suggest that a very good thing to try in this connection would be to actually produce, if possible, an arc with a sine curve wave—that is, hold the sine curve wave by a large resistance in the circuit or by self-induction, and then investigate the characters in a similar manner. Of course the arc would probably deform it some. I can readily understand that the reason for the curve of current taking the form it does is that the resistance of the arc falling with the increase of current, naturally the moment it begins falls to a point only limited perhaps by the capacity of the apparatus feeding the arc—that is, the vertical line shown in the curve of current representing the arc shows that the moment the arc starts there is practically no limit to the current which might pass through that arc if the electromotive force was not extraordinary. That is, under constant potential there would be no limit that would naturally be expected. There is one matter in connection with the photograph that I might mention here. I do not think you can argue absolutely that the current stops or that there is an absolute cessation of the arc because the photograph doesn't show it. It may be that the current flowing is so small as not to give actinic luminosity to the stream, but it is also well known that a photographic plate to develop strongly requires a certain amount of actinic work done on it—that is, taking the ordinary case of a sensitometer used to determine the sensitiveness of the plate. If you take such a sensitometer, consisting of a number of porcelain squares, and expose it to light, you will find a development up to a certain number, and after that a quick change—that is, there is a certain quick development after a certain amount of exposure so that the plate may be resistant up to a certain point and give way when the light has reached the plate in a certain amount. It may be, as Mr. Mailloux suggests, a sort of coercive force in the plate. I am reminded of the photograph exhibited some few years ago of electric sparks. Some cases of the photography of a spark give a reversed image—that is, giving a dark image on a comparatively light ground. There we have the case of another action of the photographic plate, which is solarization—that is, too much light will cause sensitiveness also. Some of the results seen here may admit of such an interpretation. I notice in the lower part of Fig. 5 what seem to be little dark spaces in between the wider black spaces, and in Fig. 6† that seems rather startingly shown; and the question there arises whether that is really due to the drop in luminosity, or whether it is due to solarization; but as the curve of current shows a depth there it probably is due to the drop in luminosity and not to solarization. Still that would be a matter to be taken into account in all these cases. The results are certainly very interesting, and the field of work is one which is certainly of great interest to those connected with the application of arcs in practice. Results certainly show that the acuteness or sharpness of the sound—the noisiness of the arc—is increased by the fact that there is a tendency to absolute break. We can readily imagine that if the curve of the current was a sine curve that the note given out would be a very smooth, musical note, but in the case before us, where the results seem to indicate almost an absolute break in the current, we can understand that it is like a set of lashings of the air, and the noise produced would be sharper and harsher to the ear in consequence. This nuisance of harshness might probably be ameliorated by the suggestions that I made at the start, by actually forcing the sine curve current through, keeping it as near as possible the sine curve current.

Dr. OTTO A. MOSES: There is one feature of the arc that I do not recollect to have seen touched upon by any of those who have studied the subject, which I think is here illustrated and perhaps elucidated. The material transmitted, whether with a continuous or an alternating current, from one pole to the other is a volatilized hydrocarbon gas. In that case we have this phenomenon—a column of gas rising or falling, according to the direction of the current, surrounded by an envelope of oxygen. That is an element not to be neglected. We have, of course, in the oxidation of the hydrocarbon a cause of luminosity independent of the current passing. The interior of such a column of gas would naturally present, through photographic influence, a dark spot.

Prof. E. L. NICHOLS: The photographs in this case were secondary to observations with the revolving mirror. I should hardly have ventured to interpret photographs alone, because I am well aware of the difficulty of so doing. But a view of the arc in the revolving mirror makes it evident visually. All that can be said is that the mass is so very small that it doesn't take an appreciable time to cool below the point at which it gives out light. That is the meaning of extinction in the way I used it.

Mr. CARL HERING: I would like to ask in regard to Fig. 12, whether it was placed east or west or north or south in the magnetic field, and, at the same time, whether it was a battery current or a pulsating current.

Prof. E. L. NICHOLS: Fig. 12 represents a continuous current arc in the same strong magnetic field which was used in Figs. 9, 10 and 11, so that that flaming on the side shows that there were two elements moving in one direction and one in the other, and that it was placed east and west, and was under the influence of an artificial field. The lines of force might be considered as parallel to the paper and horizontal. It was a current from an Edison machine—a single lamp with resistance in series sufficient to cause it to regulate properly—probably rather a smooth current.

* Part of a discussion upon Prof. Nichols' paper on this subject, presented at the meeting of the American Institute of Electrical Engineers, May 20, 1891. For the full text of Prof. Nichols' paper see THE ELECTRICAL WORLD, May 30, 1891.

† See THE ELECTRICAL WORLD, May 30, 1891.

The Practical Aspects of Electric Welding.*

BY PROF. ELIHU THOMSON.

I would say that my time has not been very closely given lately to the applications of welding processes in the arts. That department of the work has been very ably taken care of by Mr. Lemp, whose paper the Institute heard last year.† Of course I have inspected the machinery as each type was brought out and made suggestions constantly on this or that point, and may be considered, therefore, as a sort of privileged observer of results. There are gentlemen here also who may be able to give you more information in regard to the development of the business than I. I would say, however, in general, that the tendency in the development of electric welding seems to be to produce new processes or to give rise to new applications of mechanical principles such as are seen in the wheels before us. There we have practically a development of a system of work depending entirely upon electric welding, and that seems to be the direction in which it is to grow most rapidly. Naturally, when it comes to supplanting ordinary processes of welding, there is that inevitable prejudice to overcome and at the same time the reluctance of the manufacturer to throw aside a plant which he already possesses, and which does his work, in a sense going to something entirely new, putting in an extensive electrical plant which he is afraid of for fear, perhaps, that something may happen to it, and it may require repairs. He prefers that his neighbor shall get all that kind of experience before he takes hold himself. That is very natural indeed, and it simply means that in certain directions the electric welding operations will probably be slower than they would otherwise be. But with the special cases, many of which you have had mentioned in the able paper presented, you could see for yourselves that there is a direct and easy growth.

In relation to the wheel in which the cast hub is joined to spokes there is one point I might mention, that the possibilities are very well shown in that wheel of performing a number of welds at one operation. There we have the spokes set in place in the machinery and radiating toward the hub, and the machinery grasping the spokes separately, welding them all at one application of current, so that we have a number of welds all in multiple, as it were. The other case is an excellent example of a different procedure, where the spokes are caught as it were, and pinched between two surfaces which are being welded, and are therefore securely fastened. These are isolated examples of what processes are capable of being performed by the new art.

In regard to the changes of structure which are undergone by materials subjected to the welding process, that was, of course, noticed rather early. It was particularly prominent in the case of hardened steel, which underwent a decided change in the welding. It would naturally be expected that whatever change was due to the application above a certain heat would be found in this metal at the weld. It would also be naturally expected that such action might proceed back from the weld a certain distance, or, in other words, that if this had been tool steel that had been made under the hammer or in rolling, and had been given a certain texture by that mechanical knead or by the hammer, that a relaxation of that texture or a change of that texture might occur for a certain distance on each side of the weld. That is an actual fact. A tendency to granulate, of course, comes in there. The old idea was that the steel was burnt, but I have tried this operation in a hydrocarbon atmosphere, and it occurs there just as well, so that it is not a burning process. It is not a burning operation. It is simply the relaxation of the molecules, the change of physical condition, or perhaps the chemical combination brought about by the high temperature. To a certain extent that action occurs with other materials, and of course with fibrous drawn copper it is the case. Any metal whose properties depend upon the working, any metal a portion of the strength of which is due to having been drawn or hammered, of course undergoes that relaxation or rearrangement or tendency to granulation, such as is found in a casting where the metal has undergone the melting process and has been allowed to cool afterward. It is also a noticeable thing that we can take a bar of wrought iron and put it in the welding clamps and pass a current through it, heating the ends and carrying it to such a temperature beyond the welding temperature as will actually change its nature. It can be made by carrying it to a sufficiently high temperature to be a spongy, burnt mass as we might call it. That is, the temperature has been made so high that the iron, like the steel, undergoes a change of condition and does not return on cooling. I attribute that largely to the fact that in the ordinary operations of the working of the iron the temperature has been below that point—that is, the iron has been made below that point in the furnace operations—and that when we raise the temperature beyond the point of the making of the iron we set free occluded gases which have been in the iron. We make the iron puff out, as it were, in a spongy form by setting free the hydrogen gas between the fibers, or at least in the substance, and consequently the iron breaks very easily there. We find it is full of minute cavities which show that the occluded gases are removed.

Another feature of the welding operation has been mentioned which is interesting, which is that some materials when put together do not mutually yield during the heating; one, as it were, overlaps the other—the reverse riveting, as it has been termed by Dr. Perrine. One melts or softens and slips over the other. For many purposes that is a very strong joint, particularly if the burr or expansion is not removed. There has been no change of form or very little change of form at one bar. To be sure, if the enclosed bar does not change at all the union may be a perfect one. It may be that the outside piece in fusing over the other has brought just the same intimate relation of molecules of one and the other bar as though this had undergone a deformation or change. But in most cases it would naturally be expected that the best joint would be produced by, as it were, bringing to the front new molecules, perfectly clean, and unchanged molecules from the interior, in contact with the molecules of the other bar, which are also spreading and moving, and that is actually true. Advantage has been taken in a few instances of this kind of action to make a joint by cutting a number of steps in one metal and causing the other, as it were, to dovetail itself by a simple flowing over, and that in some instances makes an excellent joint. The metal flows over and fills all around, and if it has any tendency to unite, such as iron and brass have, or brass and steel, of course the union is very strong. We have all this surface, and the tensile strength of this ring, which may be steel, the brass filling the cavity, or in some cases it may be reversed.

It is curious to notice how prejudice stands in the way sometimes of the best results. There are undoubted cases where the burr or extension left by the welding operation would be best left on because there is an increased section there, and unless this is going to be very well and heavily forged the strength through the weld will be greater, and the bar will rarely, if ever, fail through the weld, but from the mere habit of not seeing things done that way, where that extension would not do any harm if allowed to remain, people want it removed. It could in many cases be forged up to form a handsome bead, but in most cases it must look like the ordinary scarfed weld or it is not altogether marketable. That I think is a temporary condition for many cases of welding. It will be gotten over finally. Dr. Perrine has brought out that fact in relation to the telegraph wire, where formerly they were content to take the double twist joint with all the metal which is involved, and when they got this to take the place of that they were not content. Their self-induction was high, and nothing would satisfy them but that that should be removed, which was, of course, a simple thing to do, either by forging it down or grinding it off.

One further point in relation to the upsetting for copper, the structure of which has been changed. This might represent a copper joint made on rather large copper. Now, naturally, if that joint has been formed the copper has been heated back here some distance on account of its high conductivity for heat, and if that part of the metal has a structure due to mechanical working, that structure is partly lost if not entirely lost at this point. It is desirable, on account of the resistance to strains required for some purposes, that it should be restored. I found in the early days that I could swell up by taking the clamps apart a lit-

* Part of a discussion of Dr. F. A. Perrine's paper on this subject presented at the annual meeting of the American Institute of Electrical Engineers, May 20, 1891. For Dr. Perrine's paper see THE ELECTRICAL WORLD, May 30, 1891.

† See THE ELECTRICAL WORLD, June 7, 1890.

tle, swell up a certain amount of material and then hammer the mass down to its original condition. But when that comes to be attempted in rather large stock you can readily see that the power required is considerable. We must be able to take hold of that bar very firmly indeed, and we must have hydraulic pressure without any slipping to force up a mass of material at a rather low temperature, because if you heat it to too high a temperature the difficulty is that you do not upset the spoke far enough back; you require to take in almost the cold metal in the upsetting process, and then forge it back to the original shape when you get the fibrous structure put back. That probably can be done by taking hold of a sufficient length of bar each side and putting guides on each side of the work so that it will not buckle out of shape and take hold; in other words, at a number of points by multiple clamps, and then force the metal up. If we should use notched clamps there is an objection at once, because we do not want any injury done to the exterior surfaces. We have to use a smooth clamp, a clamp which will not bite into the material and change its surface. That would require another operation to remove the notches, so that we would probably have to take a foot or more of the bar, plant it firmly in clamps fitted closely to the work, and then force it, risking the slip. Of course, we cannot get an end pressure on a bar which may be very long—may be 100 or 200 feet, or more than that, and a very long coil also—so that we have to get whatever we can by hydraulic pressure, and risk any deformation that takes place.

The Perfection of Stationary Electric Motors.*

Prof. W. A. Anthony: Prof. Crocker certainly has not laid too much stress upon obtaining a large surface of contact between the wrought and cast iron in forming a joint; and even in making a joint between two wrought iron pieces, it seems to me that a large surface of contact is needed also, for any amount of machine work that it is practical to do economically does not produce anything like the surface of contact that you would have in a field magnet made up of one piece. For instance, suppose the pole piece and the core were joined by means of a joint in this case—I venture to say that with any joint that it would be practical to make there economically you would not have one-quarter of the surface of contact between the two metals that you have when you make it of a solid piece.

Prof. Elihu Thomson: With reference to the contact between the cast iron and the wrought iron, Prof. Crocker is certainly right in saying that there must be a large amount of surface contact, and that the difference between those surfaces must be a minimum—that is, they should be in very close contact. Now, in order to get the same amount of surface there would have to be a flange or something of that kind. That would occupy a great deal of space. It seems that the advantage that he pointed out then would be that he takes that flange, as you might say, and puts it in a hole, and takes out some of the cast iron. In that way he gets the same amount of surface and gets the same close contact, and yet it occupies less space, simply because he takes out some of the cast iron and puts the wrought iron in. Of course, by means of inserting these the contact would be closer than you could ever get by any bolts. I do not know whether they were fastened in there by the principle of contraction by cooling or whether they are simply driven in.

Mr. C. O. Mailloux: It might be well to state, in connection with this subject of joints, that it was carefully and somewhat exhaustively gone into in Europe about a year and a half ago. The results of that investigation were reported in the scientific press. It was found that the character of the contact made a great difference so long as you confined yourself to rather low densities—low degrees of saturation of magnetism—but when once the density became large the apparent effect of defect of joint did not make very much perceptible difference; that so long as you had low densities it made considerable difference, but when once you reached saturation, or any degree approaching thereto, it practically didn't make very much difference. These two points are of some importance, and as the results were gone into carefully, I think they are worthy of study. I think it would also be well to emphasize the point noted by Prof. Crocker as to the usefulness of teeth in producing a retaining point on which the wires can act to pull the armature. We know that the current acts upon the wire and not the core, and that consequently it tends to displace the wire and not the core. This is of the more importance the slower the speed of the machine. As we reduce the speed of the machine we must reduce the torque in order to increase the power output. I have recently designed machines where the peripheral pull is as much as 2,400 pounds on the armature. You can readily see there that it would be almost impossible to undertake to confine the wire and to be sure that it would remain in the same relation with the armature core, unless the armature wire is laid in slots or otherwise securely fastened mechanically to the armature core. The point made by Prof. Crocker in relation to the lamination of pole pieces I think is very well taken. It has been my experience that the laminating of the fields and pole pieces is not only a very expensive process, but a very unsatisfactory one, mainly for mechanical reasons, to say nothing of the question of cost. It involves mechanical expedients that are not necessary when solid cores are used. The eccentricity of the field is another important point, and it has one advantage which I think Prof. Crocker did not mention, namely, the fact that it tends to retain the lines of force within the sphere of the field-space rather than to allow them to crowd in towards the corners. It is a well-known fact that the lines of force are crowded by the action of the current toward the entering horn of the motor and the following horn of the pole piece of the dynamo; in other words, that the horn of the pole piece which is nearest the armature is always that which gets the warmer of the two pole pieces. Now, the effect of making the field eccentric is to increase the magnetic reluctance at that point, and it consequently tends to prevent and counteract the tendency of the lines of force to crowd at any particular point of the core. It prevents the tendency to increase the density at any particular part of the core, and consequently it reduces the tendency to Foucault currents. It has also a marked bearing on sparking, because it equalizes the potential from the positive to the negative side of the commutator. You get a better curve. Another thing is that you don't get so much action near the neutral point, and consequently you very greatly reduce the sparking. With regard to the trapezoidal teeth, I quite agree with Prof. Crocker that there is an advantage in endeavoring to increase as much as possible the peripheral surface of the armature, for obvious reasons. There is, perhaps, one point to which he has failed to call attention, and that is the relation which the shape of the teeth and their form, etc., bear to the sparking of the machine. I have had considerable experience with Pacinotti armatures, and I have noticed that the shape of the teeth, their number, also the clearance, have a definite relation to the sparking. Mr. Essen, in England, has recently pointed out that there is a relation between the armature carried and the space which must be allowed in the air gap, in order to eliminate sparking, and in order to increase, as far as possible, the limiting current of the machine, because it is found that under certain conditions, when a certain excess of current is reached, which can be calculated for each machine, that sparking occurs; and this is related very closely to the shape of the armature when it has teeth. But the explanation which Prof. Crocker gives of the action of that peculiar form of tooth is perhaps not as full as it might be. There is no doubt whatever in my mind, judging from my experience and the study of the subject, that the form of teeth which he has there not only has the mechanical advantage, but it has also a direct influence in reducing sparking; that with such a small number of teeth as he is using, it would not be safe for him to make these slots of the ordinary proportion, because he would doubtless find that he had very serious sparking. The sparking phenomenon is connected directly with the track of the lines of force to the end of the pole piece; and as they are all released in large quantities, you get a very material amount of sparking. You perhaps know that in the Oerlikon machine the problem has been overcome in another way, viz., by making a hole near the periphery and passing a wire through it; and I have understood that in such machines there is very little sparking; that they have the great advantages of allowing a very small clearance, and that in other words the relation admissible between the volume of current around the armature, as Mr. Esson terms it, and the clearance space is not different, and allows of the current being greatly increased.

Mr. J. Martin: In regard to the surfaces of the cores and yokes in the magnetic circuit I would state that the old practice of the Edison company was to scrape them just as accurately as possible. That practice has been abandoned, and the present machines turned out I believe are simply planed and turned off. In testing a machine within the past two months I did not get out of it quite as much as I was anticipating, and in looking over the construction I found there was quite a little dirt in between the surfaces. I cleaned them off very carefully. I found there was no appreciable difference. There was probably half or one or two per cent. which would not be noticed within the range of speed variations. But practically there was no difference at all. In regard to the heating of machines, I tested a machine a short time ago in which the heating effect was very considerable. In fact, by starting a machine up on a load, which from the results of previous tests gave it maximum capacity at full temperature, I measured the actual watt output on the start, and three hours later this machine heated up to its maximum capacity. The watt output was reduced exactly one-third. This was a small machine and not very efficient, but I merely give it as an instance to show that the heating effect of a machine should have considerable attention paid to it. I would also state that the method which I have used myself and have noticed other people using, of measuring the heating effect of a machine with a thermometer, is very unsatisfactory. In fact, it is very hard to attain an exact result. I think the best way to do this is probably to measure the increased resistance of the coil and then to check back by the well-known formula,

I am glad to see that Prof. Crocker put considerable stress on the value of continuous and reliable running irrespective of a few per cent. of efficiency. The people with whom I have come in contact in commercial work when they were at all pressed for work would rather pay four times the price for power than have the machine shut down for even two minutes. I would like to ask Prof. Crocker, or any one who has had the experience in the designing of machines of this Pacinnoti type, whether the decrease in magnetic resistance of the air gap has any particular detrimental effect on the balance between the field and the armature. I think in certain cases it might have. I think there is a certain balance to be obtained between the armature and the field, and that it is possible in machines in which the magnetic resistance in the machine as a whole is very largely reduced, especially if you take as a type the high output machines designed by Messrs. Crompton and Swinburne. I would like to know if the particular shaping of the cross section of the pole pieces is the result of experiment. I understand that in some of the types of this machine there are two coils wound in the same slot. I should like to ask if those coils are proportioned so that they will have an equal resistance and will not buck against each other when they are short circuited. I also noticed that the tips on the outer end of the poles are closer together than on the inside at the end of the spool. I should like to know if that is the result of calculation. The tests alluded to by Mr. Mailloux as to the effects of joints in circuit were published in The Electrical World during the past year, and are also very fully reported in Prof. Thomson's book on "The Electromagnet."

Dr. Louis Bell: I remember once testing a form of machine of the Manchester type, and putting the magnetized coil on one limb and the testing coil on the other. The joints were straight and screwed together, but rather carelessly, so that there was a considerable layer of oil between the faces, and the bolts were not tightened as they should have been. It seemed to me that the permeability was very much less than it ought to be. On taking it apart, and putting it back and screwing it up tight, the difference was much larger than I supposed—something like 20 per cent. That simply brought out a point that was shown—very nearly shown, at least—in some of the early English investigations on this subject three or four years ago—that the question of pressure alone would determine the magnetic resistance of the joint more than almost anything else; that up to certain pressures—quite considerable ones—the joint would make a very serious difference, and that finally a point would be reached where it would make almost none.

Prof. Crocker: I simply stated in a general sort of way that a good joint was desirable, which I think no one will deny. The resistance of the joint I think is properly stated to be equivalent to an air gap of half a thousandth of an inch, or, as it is expressed by Thompson in his recent book, as equivalent to so much of the iron circuit. The advantage of expressing it in terms of air gap is, that air has the permeability of one, and is definite. But I spoke of the necessary surface of contact between wrought and cast iron. If cast iron has fifty or sixty per cent. of the permeability of wrought iron you would have a corresponding increase of surface of contact, joint or no joint. If there was a welded joint between the two, it would still need to have that increased surface of contact. That is a different thing from the question of joint between two separate pieces, and that is the thing that I was particularly insisting upon. Incidentally we do obtain a very good joint because that core is made exactly true and exactly to a certain gauge. And so is the hole into which it fits, and that slips into there absolutely with no lost motion at all. That means that the feed is right within a fraction of a thousandth of an inch, and I think such a thing is desirable, particularly where your magnetic circuit is of low reluctance. I have made a test in which you could slip a visiting card into a joint due to the fact that one side was kept out by a little piece of dirt, and yet when you made the joint perfect it made no perceptible difference, because the rest of the magnetic circuit has such a large resistance that that was of no consequence. But if the rest of the circuit has a small resistance it is of great consequence. In regard to the pole-piece device being brought nearer to the upper side, I would say that the object of that is to equalize the tendency of a greater number of lines of force to go through the narrow side. I find it is so, and that we get 50 per cent. of the lines of force through the middle of the pole piece. The object of the plow form of the pole piece is to make the teeth come into the field gradually. That pointing action does it, and the increased distance also has the effect of making gradual the entrance or exit of the coil or tooth, and I think that quite important, particularly in toothed armatures. What Mr. Mailloux said agrees exactly with my experience that toothed armatures should have a flaring pole piece and should have a rounded pole piece also. It is also desirable, both on account of the effect of sparking and keeping the lines of force in the middle of the armature rather than have them pile up in one corner. Another thing is that if you have a perfectly square edge and a perfectly square tooth it will produce a hum, due to the sudden effect produced when the edge of the tooth comes opposite the edge of the pole piece, but if the edge of the pole piece

* A discussion of Prof. F. B. Crocker's paper on this subject at the meeting of the American Institute of Electrical Engineers, May 20, 1891. For Prof. Crocker's paper see The Electrical World, May 30, 1891.

has no definite position and the passage is gradual then the hum is reduced. In regard to two sections in one slot, I would say that we do not equalize it, and I expected a tendency to spark in one of them more than in the other. That is to say, I expected to have the sparking of the armature indicate that there were two sections on one slot, but it doesn't seem to occur.

The Magnetic Circuit of Transformers: Closed versus Open.*

BY S. EVERSHED.

(78) So much for the theory of idle current supply by condensers. It is too soon to expect any practical results of importance, but there is no reason to expect any insurmountable difficulties in making large condensers capable of withstanding 2,000 volts or more. Meanwhile it may be useful to give a rough calculation of the probable dimensions of a condenser to supply one ampère at 2,000 volts with a frequency of 100 ~. According to our formula,

$$K = \frac{C}{2\pi E F} = \frac{1}{2\pi \times 2{,}000 \times 100} = .8 \text{ microfarad.}$$

This must be converted into electrostatic units before we can determine the size, number and thickness of the dielectric films. One microfarad is equal to 1×10^{-15} C. G. S. (magnetic units), and to convert this into static units it must be multiplied into v^2, or $(3 \times 10^{10})^2$, so that

$$\begin{aligned} .8 \text{ microfarad} &= .8 \times 10^{-15} \times 9 \times 10^{20} \\ &= .8 \times 9 \times 10^{5} \\ &= 7.2 \times 10^{5} \text{ electrostatic units.} \end{aligned}$$

(79) If each film has an area of 1,000 square centimetres (roughly one square foot), and a thickness of .05 centimetres, and if we further assume the dielectric constant to be about twice that of air, the capacity per film will be

$$\frac{2 \times 1{,}000}{4\pi \times .05} = 3{,}200 = .032 \times 10^{5}.$$

and $\frac{7.2}{.032} = 225$ nearly enough, so that it would require 225 films of dielectric to supply one ampère. If the conducting plates are half the thickness of the films the total thickness of the condenser will be nearly 17 centimetres. Such a condenser would go into a box 14 inches × 14 inches × 8 inches, but this is the size wanted to supply one 10 h. p. open transformer—No. 2 as a "hedgehog" required about .9 ampère—and a fair output for a central station would mean from 50 to 100 such condensers, but even then the space occupied by them is not a very serious matter. Of course, a dielectric may be discovered, a very thin film of which would suffice to withstand 2,000 volts; but it is reasonable to suppose that in the fierce race for the best covering for high-tension mains all the really serviceable materials have already been unearthed. It is curious that one of the best materials, from a mechanical point of view, turns out to be about the worst electrically. In seeking for a strong dielectric one naturally expects to find glass a throughly satisfactory material. It is usually supposed to be capable of standing enormous electrical stresses, though so far as the writer is aware no determinations of the potential differences required to pierce glass of given thickness and composition have ever been published, and he can therefore only quote from results noticed by himself while using a large induction coil. The coil terminals being connected to glass Leyden jars, it was noticed that when the latter were giving sparks some three or four inches in length they would usually burst after a short time, although a jar here and there would successfully stand the enormous force. The glass of these jars was about .5 centimetres thick, and taking a four-inch spark to represent 100,000 volts, we may conclude that 200,000 volts per centimetre is certainly very close to and probably beyond the breaking stress for the glass of which these particular jars were composed. Taking this figure as a guide, a glass film .015 centimetres thick would be at its breaking point with 3,000 volts, or say 2,000 effective volts from an alternate current circuit. Allowing a factor of safety of 4, the films would require to be about .06 centimetres thick. The dielectric "constant" for glass is one of those puzzling quantities which are only called constant because it would be so extremely convenient if they were so. The specific inductive capacity for glass is given by Fleeming Jenkin (Electricity and Magnetism) as 1.9, while Dr. Hopkinson found values ranging from 6.7 to 9.9. The true constant might be expected to be equal to the square of the refractive index for infinitely long light waves, and the index for the glass used in Hopkinson's determinations is given as ranging from 1.5 to 1.6 (Fleming's "Alternate Current Transformer," Vol. I., p. 345). These figures indicate the value 2.5 as the electric constant required by the Maxwellian theory. It seems probably that the large discrepancy between this value and those observed by Dr. Hopkinson is due to something akin to electrolytic conduction, in which case we should expect glass to ultimately break down from decomposition, even supposing it able to stand without cracking the rise of temperature due to the local conduction currents in it. Evidently glass has too complex a composition for use in alternate current condensers.

(80) Since writing the above Mr. Swinburne has described the progress made by Mr. Bourne and himself in the search for dielectrics, in a short paper read at the Physical Society. The best results have been obtained from paper saturated with some hydrocarbon oil, and probably condensers made on some such lines will ultimately come into general use. One small difficulty not apparently noticed by Mr. Swinburne in the course of his experiments is that most hydrocarbon oils contain traces of the acids used in refining, and this naturally tends to diminish their specific resistance. Solid hydrocarbons, on the other hand, while excellent in their insulating quality, are liable to crack, and any discontinuity in the dielectric film is fatal. We may take it for granted, then, that condensers are quite feasible. Their cost is another matter altogether, and one which time alone can settle.

(81) We are now in a position to give some sort of answer to the question we set out to discuss, namely, which are the more economical, closed or open transformers? Perhaps the best way of putting the conclusions arrived at before the reader will be simply to consider the annual cost of the power wasted in the cores of the typical transformers which have served as examples in these papers. Take the case of a supply company running a 600-kilowatt station. According to the figures adduced by Mr. Crompton, in his celebrated paper on central station lighting (Journal Soc. Tel. Eng., vol. XVII., p. 361), the total cost of the plant, inclusive of mains and transformers, would be about £60,000. Suppose, for the sake of argument, we assume Mr. Crompton's coefficient to be nearly two, and put the capital outlay at £100,000 for the 600-kilowatt plant. The maximum transformer capacity must be about 1,000 h. p., and we may conveniently divide this into 100 transformers of 10 h. p. each. If the Ravenshaw transformer is used with its original winding, the core waste will amount to 9.6 B. T. units per diem, or 3,500 units per annum per transformer. It is impossible at present to obtain reliable information as to the actual running expenses of alternate current plants, but it has been stated at about fourpence per unit delivered to the consumer; but in reckoning the cost of waste power it is clear that we must only take the coal and oil consumption into account, the only appreciable saving to be effected by a diminution in waste power be-

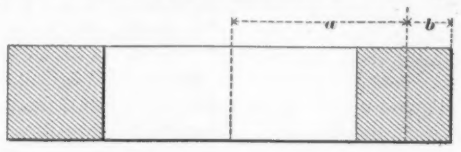


FIG. 25.—SECTION THROUGH CIRCULAR COIL FORMING PRIMARY AND SECONDARY WINDINGS OF 10 H. P. CORE LESS TRANSFORMER. ONE-TENTH FULL SIZE.

ing in cost of materials. Wages and fixed charges remain as before. Probably one penny per unit is a reasonable sum to allow in the case of waste power. At this rate 3,500 units will cost about £15; that is to say, the company will virtually spend £1,500 per annum in heating the cores of its transformers. This, let it be remembered, is a fixed charge depending solely on the design and average size of the transformers, and not at all on their useful output. They may run at full load continuously from one year's end to another, and the engineers of the company may point with pride to the 95 per cent. efficiency of their converters, but the waste goes on just the same, and the company which succeeded in cutting down the whole of the core waste would add nearly 1½ per cent. to its dividend.

(82) Replace the transformers by the No. 2 closed modification, wasting 3.94 units per diem or just under £6 per annum; the waste in 100 such transformers will be £600 per annum, as against £1,500 for the original transformers, a clear gain of £900 per annum. But there is the additional capital outlay in copper. The saving in running expenses is effected by putting something like 180 pounds more copper in the coils, adding perhaps £25 to the price of each converter, so that for an additional outlay of £2,500 a saving of £900 per annum is effected. Evidently a good investment. Will it pay to convert No. 2 into a "hedgehog" like Fig. 15? So far as the transformers themselves are concerned it certainly will. No. 2 as an open transformer with small "hedgehog" ends (Fig. 15) wastes 1.94 units per diem in its core, to which the constant C^2R waste for exciting current must be added, bringing the whole constant waste up to 2.14 units, costing £320 per annum for 100 such transformers. This is an additional saving of £280, compared with the same transformers with closed magnetic circuits. Of course one cannot be sure of this saving unless the idle current is supplied by condensers, so that the light load may be taken by a portion of the station plant fairly well loaded. It should be noticed that transformer No. 2 would certainly cost less to build with an open than with a closed magnetic circuit, so that although £280 seems hardly worth saving by itself, the saving in capital outlay is an additional advantage. What that saving would be it is impossible to say, as manufacturers of electrical plants do not publish their prime costs, and list prices are generally meaningless. The whole point really turns on this: To effect any appreciable saving by means of open transformers condensers must be used. Inclusive of condensers can they be supplied at the same cost as condensers with closed cores? If that question is decided in favor of open magnetic circuits there would still be the extra complication and liability to breakdowns introduced with condensers to be taken into account. A single disaster with the condensers would probably more than wipe out the whole annual saving in the transformers.

(83) Since an open transformer is economical by reason of the small amount of iron in its core, why not take the next step and use no iron at all? The dimensions of a coreless transformer are easily calculated if we assume some convenient shape for the coils. Suppose we design a coreless transformer which shall require the same weight of copper as No. 2 (either open or closed) and work with the same resistance drop, namely, 2.8 per cent.; the problem then reduces itself to finding the size of a bobbin on which to rewind the coils used in No. 2, and, as we want to keep down the exciting current to its smallest possible value, we must evidently wind the wire so that the product of induction due to unit current into the number of turns on the coil (in short L) is a maximum. A solution of this problem has been given by Gauss, but it will be better to work it out here independently.

The self-induction in a coil whose average diameter is large compared with the cross-sectional area of the winding is approximately

$$L = 4\pi N^2 a \left(\log_\varepsilon \frac{8a}{R} - 2\right), \qquad (1)$$

where N is the number of turns of the coil, a is the average radius and R the average distance of the wires from each other (geometrical mean distance). We may take the cross section of the bobbin as being square, as shown in Fig. 25. The area of the section is $4\,b^2$, one-half of which may be taken to represent insulation, the remainder being available for copper. In calculating for minimum exciting current we have only to deal with the primary coil, the copper of which will have a cross-section equal to b^2. Its volume is known, for, as we have 240 pounds of copper on No. 2, we may assume that we shall use 120 pounds on the primary, or the volume will be

$$V = 6{,}055 \text{ cc.}$$

The primary and secondary, being supposed to be well mixed, will each cover the whole cross-section, so that the geometrical mean distance of the primary winding from itself will be

$$R = .447 \times 2b = .894\,b.$$

(84) From these equations we are able to eliminate N and a from (1), for

$$a = \frac{V}{2\pi b^2}$$

and

$$N^2 = \frac{rb^4}{\rho V},$$

where ρ is the specific resistance of copper, and r is the resistance of the primary, which must be 7.6 ohms to make the full load drop equal 2.8 per cent. as before. Substituting the values of N^2 and a so determined, we get

$$L = \frac{2rb^2}{\rho}\left(\log \frac{4V}{.894\,\pi b^2} - 2\right), \qquad (2$$

so that

$$\frac{dL}{db} = \frac{2r}{\rho}\left\{2b\,(\log 4V - \log .894\pi - 3\,\log b - 2) - 3b\right\}.$$

The right-hand side vanishes if $b = 0$, which is an impossible but obvious solution, and the maximum we are seeking occurs when $\frac{dL}{db}$ is made to vanish by writing

$$\log 4V - \log .895\pi - 3\,\log b - 2 - \frac{3}{2} = 0; \qquad (3)$$

solving (3) for b we find $b = 6.38$ cms.,

and therefore $a = 23.7$ "

$R = 5.7$ "

$N = 1{,}100$ turns.

With these values we can determine the induction threading the coil due to one ampère, for

$$L = B_{10}\,N,$$

where B_{10} is the induction for 10 ampères (c. g. s. unit), and putting real values into (1) we find:

Induction per ampère = 49,500 thoms.*

If the coil is run at 2,000 volts, at a frequency of 70~, the exciting current will be given by the equation

$$B' = 49{,}500\,C' = \frac{2{,}000 \times 10^8}{4.4 \times 1{,}000 \times 70},$$

from which $C' = 15$ ampères,

or $C = \frac{12}{\sqrt{2}} = 8.5$ ampères.

(85) Of course, no one would dream of working with an exciting current more than twice as great as the full load current, which for 10 h. p. is 3.75 ampères. To obtain a reasonable exciting current we may either use more copper or raise the frequency, and we will adopt the latter expedient, for, there being no core, there is no reason for running at a low frequency, at least so far as the transformer is concerned. Neither is there any reason to reduce the exciting current below that required for No. 2 as a "hedgehog," namely, .9 ampère. The exciting current being inversely proportional to the frequency, we must raise the latter to—

$$F = 70\,\frac{8.5}{.9} = 660 \sim \text{per second.}$$

This is far higher than anything yet adopted in practice, and at such a frequency eddy currents in every part of the system, from alternator to transformers, would be a serious item. But the whole of the exciting current is idle in

* Concluded from THE ELECTRICAL WORLD, May 23, 1891.

* One thom = one "magnetic line of force." B throughout this investigation stands for *total* induction.

a coreless transformer, and if it is supplied by a condenser we may arrange the frequency so that the condenser used for No. 2 would serve for the coreless transformer, for the idle current output of a condenser is directly proportional to the frequency. To find the appropriate frequency to fit the condenser required by No. 2 we have, first, the following data:

Condenser supplies .9 ampère at 70 ~

It therefore supplies $\frac{.9}{70}$ ampère at 1 ~

Or current supplied by condenser at frequency F is:

$$C = \frac{.9}{70} F. \qquad (1)$$

Also, as we have seen the frequency needed to make the exciting current equal to .9 ampère was 600 ~, so for a current C it must be

$$F = 660 \frac{.9}{C} \qquad (2)$$

Eliminating C we have

$$F^2 = \sqrt{660 \times 70}$$

and $F =$ 215 ~ per second,

and therefore $C =$ 2.76 ampères.

(86) The frequency just found is by no means excessive, although somewhat higher than is now generally considered advisable. The efficiency of the coreless transformer is very high in spite of the large exciting current. At full load it is as follows:

Output	7,500	watts.
C^2R for exciting current	50	"
C^2R for load	212	"
	7,770	

$$\text{Efficiency} = \frac{750}{777} = 96.5 \text{ per cent.}$$

and on the time load assumed throughout these articles its efficiency works out thus:

Output	24,000	watt	hours.
24 hours' C^2R for exciting	1,390	"	"
6 hours' C^2R for load	360	"	"
	25,750		

$$\text{All day efficiency} = \frac{240}{258} = 93 \text{ per cent.}$$

(87) Coreless transformers have many advantages. They are necessarily less wasteful than any other form of converter; they are far simpler to build, the trouble of insulating the coils from the core vanishes with the core, and the power wasted is so small that the transformer would keep perfectly cool. The 10 h. p. coreless transformer just described would occupy a space of about two feet diameter and six inches deep, and it is difficult to imagine a safer arrangement than such a bobbin placed in an earthenware pan filled with oil and closed by an oil-tight lid. There are some disadvantages, perhaps serious ones; the high frequency leads to difficulties in designing alternators, and all eddy current effects would be nine times as great at three times the frequency, and this may easily become a serious matter. Some trouble also would probably arise from the induction due to the load currents in the primary and secondary coils unless the windings were thoroughly mixed. The engineers of a company which had an eye to good dividends in spite of competition might be expected to overcome all these obstacles, though it is in the last degree unlikely that any directors will sanction an increase in capital outlay for the sake of a moderate saving in working expenses, until they have to supply energy at fourpence a unit or lose their trade. When that millennium arrives, and it most certainly will, the directors will worry the engineers. In the meantime it is clear that the condenser is the key of whole question. If condensers are practicable, open cores for transformers will supersede closed magnetic circuits, and both may have to give place to the coreless transformer.

The Measurement of Electric Power Given to an Inductive Circuit.*

BY DR. J. A. FLEMING.

The ingenious method proposed by Messrs. Swinburne, Ayrton and Sumpner for the measurement of the electric power given to any circuit by any electric current, by means of three voltmeters, is one which, while perfect in principle, presents certain practical difficulties in general application.

Suppose, for instance, it is desired to measure the power taken up in the whole of the transformers connected to a transformer station when under light load, and that this has to be done without interfering in any way with the lighting work. In carrying out the measurement in accordance with the proposed method, it would be necessary to provide a non-inductive resistance capable of carrying the whole current sent out from the station, and which preferably should have such a magnitude that the drop in volts over this resistance should be about equal to the ordinary drop in volts across the primary mains of the transformer station, or, at any rate, not be very different in amount. The alternator would then have to be excited to an electromotive force higher than the normal, so as to maintain the proper volts between the primary terminals of the transformers. It might be, and generally would be, impracticable to make these arrangements, and the proposed method would therefore be inapplicable in such a practical case. It is possible, however, that a modification of this method can be made which will be applicable to such cases, and will enable transformer tests to be made on working primary circuits without interfering with the E. M. F. of the alternator. It is as follows: Let x (Fig. 1) be an inductive circuit, and let y be a non-inductive circuit joined in parallel with it between two mains, a and b, between which a potential difference is maintained, which at any instant has the value v. Let i be the current in the main circuit at that same instant, and let i_1 and i_2 be the currents in the non-inductive and inductive circuits y and x also at the same instant; then we have always,

$$i = i_1 + i_2; \qquad (1)$$

hence,

$$i^2 = i_1^2 + i_2^2 + 2 i_1 i^2. \qquad (2)$$

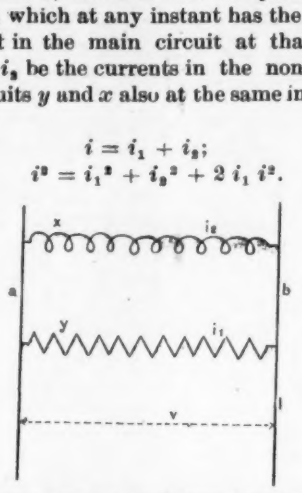


FIG. 1.—MEASUREMENT OF ELECTRIC POWER GIVEN TO AN INDUCTIVE CIRCUIT.

Let r be the resistance of the non-conductive circuit y, then

$$i_1 r = v. \qquad (3)$$

The power w taken up in the inductive circuit x at that instant is given by

$$w = v i_2;$$

hence,

$$w = i_1 i_2 r. \qquad (4)$$

Hence from (2) and (4)

$$i^2 = i_1^2 + i_2^2 + \frac{2w}{r}; \qquad (5)$$

or,

$$w = \frac{r}{2}\left(i^2 - i_1^2 - i_2^2\right). \qquad (6)$$

This last equation is true at any instant; hence the mean value of the power W taken up is obtained by integration of this equation (6), and is

$$\int_0^T w dt = \frac{r}{2}\left(\int_0^T i^2 dt - \int_0^T i_1^2 dt - \int_0^T i_2^2 dt\right);$$

or,

$$W = \frac{r}{2}\left(I^2 - I_1^2 - I_2^2\right), \qquad (7)$$

where I_2, I_1 and I are the readings of dynamometers inserted in the respective circuits x y and the main.

To reduce this method to practice, arrange matters thus: Let T (Fig. 2) be the transformer or transformers on the working circuit, and of which we wish to measure the power taken up in the primary circuit P. Put a dynamometer or alternate current ammeter a on the primary circuit, and arrange two others, b and c, as shown in Fig. 2. Let c have a non-inductive resistance in series with it (which may be a water resistance) across the mains. Arrange also a voltmeter, V, across the primary mains to measure the potential difference between them. Then the dynamometer a measures the current I_1 going through the inductive circuit, and c measures the current I_2 through the non-inductive circuit, and b measures the total current. The quotient of the reading V of the voltmeter by the reading I_2 of the dynamometer c gives the value of the resistance r in the

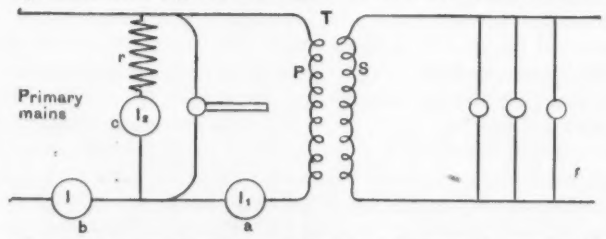


FIG. 2.—MEASUREMENT OF ELECTRIC POWER GIVEN TO AN INDUCTIVE CIRCUIT.

formula (7), and hence the power being taken up in the primary circuit of the transformer is given by the expression

$$W = \frac{V}{2 I_2}(I^2 - I_1^2 - I_2^2). \qquad (8)$$

The difference between this method and that of Messrs. Swinburne, Ayrton and Sumpner is that currents are read instead of volts, and vice versa, and that there is no need for making a call for more electromotive force than would be needed to operate the transformer in the usual way if the measurements were not being made.

The objection which may perhaps be raised to this modification of using the non-inductive resistance in shunt rather than in series is that the same cause of error will be introduced which vitiates the accuracy of a wattmeter reading of alternating current power, viz., that, even if circuit y is made to have as little inductance as possible, yet, unless it is quite zero in that respect, the very fact of being joined in parallel with a circuit of possible large inductance will prevent the current in y from being in phase with the electromotive force v. It is possible, however, to settle by direct experiment how far this is the case. Let the two methods, (i.) the one with three voltmeters and non-inductive coil in series, and (ii.), the one with three ammeters and non-inductive coil in shunt, be tried on one and the same highly inductive circuit, and note the difference, if any, in the power reading obtained. If there is no practical percentage of error, I think the method with the three ammeters will prove to have advantages in practice over the other. We want a means of determining the efficiency of house transformers *in situ*, and that without disturbing the E. M. F. of the primary circuit, and the same is the case in factory tests, where it will often be practically impossible to secure the increased E. M. F. necessary for the three voltmeter method.

* See *The Electrician*, April 17, 1891, p. 736; also *Industries*, March 27, 1891, p. 306.

Trial of a 100 Horse-Power Simplex Gas Engine.*

The trials, of which we give below the results of the longest continuous run, were undertaken by Prof. Witz in order to compare the working cost of a large power gas engine using Dowson gas with that of a steam engine of the same effective horse-power. The comparison was made between a Corliss condensing engine of 75 h. p. output and the gas engine under trial. Given a consumption of 2.35 pounds of coal per horse-power hour for the steam engine, and taking its ratio of efficiency at 11 to 20 for the gas engine, the professor states that the two sets of plant occupy about the same floor area, and that the total prime cost of the plants would come to nearly similar amounts. £1,280. Interest and depreciation are taken at 15 per cent. per annum for 300 working days of 10 hours each, while the wages of the engineman are charged equally to each apparatus. The figures as estimated are 38s. per day for the steam engine and 31.42 for the Simplex gas engine. Prof. Witz, in his estimate, has based his calculations on the cost of anthracite coal at 25s. 11½d. per ton and coke at 27s. 9d. per ton. Mr. Dowson also gives an estimate of the cost of working a gas engine of 100 indicated h. p. with Dowson gas for 250 days at 10 hours per day, quoting for the consumption of coke at 10s. per ton, coke entirely being used in place of the more expensive anthracite, the result coming out at 24.73s. per day of 10 hours.

Some trials made with Dowson gas in driving engines were carried out at Messrs. Crossley's works, Manchester. In the one case ordinary gas coke was used in the generator, and in another trial anthracite was employed. Coke gave one indicated horse-power for 1.4 pounds, anthracite producing the same horse-power for 1.2 pounds. With so slight a difference in the consumption of fuel per horse-power, Mr. Dowson considers that he has succeeded in producing his gas practically as well with the cheap fuel as with that of a more expensive nature.

RESULTS OF TRIAL LASTING 23 HOURS 30 MINUTES.

Fuel.		
Weight of anthracite used	2,030	lbs.
" of coke used	377.2	"
Consumption of anthracite per brake horse-power per hour	1.555	"
Consumption of coke per brake horse-power per hour	.214	"
Total consumption of fuel per brake horse-power per hour	1.369	"
Water.		
Quantity of water supplied to producer	34.24	cubic feet.
Quantity of water supplied to scrubber	647	"
" " " jacket	3,152	"
Consumption of water for producer per brake horse-power hour	.0195	"
Consumption of water for scrubber per brake horse-power hour	.368	"
Consumption of water for jacket per brake horse-power hour	1.793	"
Total consumption of water	2.1805	"
Oil.		
Weight of oil used in cylinder	14.71	pounds.
" of grease used in bearings	1.76	"
Consumption of cylinder oil per brake horse-power hour	.0084	"
Consumption of grease per brake horse-power hour	.0010	"
Gas.		
Total consumption of gas per hour	6,739	cubic feet.
Height of barometer during trial	772	mm.
Temperature of gas on entering engine	21.5	deg. C.
Consumption of gas reduced to 0° C., or 760 mm. per hour	6,345	cubic feet.
Consumption of gas reduced to 0° C., at 760 mm. per brake horse-power per hour	84.87	"
Brake.		
Total revolutions of engine	142,157	
Average revolutions per minute	100.8	
Diameter of brake pulley	5.576	feet.
" of ropes	.945 m. = .0788	foot.
Load on brake	1,557.4	pounds.
Mean tension of spring at tail end	173.9	"
Effective load	1,383.5	"
Brake horse-power (English)	74.82	horse-power.

The engine used by Prof. Witz in the trial, the particulars of which are set forth in the table, was a 100 horse-power Simplex gas engine manufactured by Messrs. Matter & Co., of Rouen. It is a single cylindered engine. The cylinder is 22.64 inches diameter, with a stroke of 37.4 inches. There are two flywheels mounted on the shaft. The flywheels are 11.8 feet diameter, and weigh 3.84 tons each. The normal speed of the engine is 100 revolutions per minute. The engine is a four cycle one, working with an air pressure of 85.4 lbs. per square inch. The distribution of air and gas is effected by one slide and three pot-lid valves, and the ignition is by electricity. The engine works with delayed ignition, so that the explosion does not take place till the crank is 15 degrees past the dead point. This plan lessens the strain on the bearings of the crank shaft, and also enables the ignited gas to expand more rapidly than usual, and the maximum pressure is better maintained. The engine is fitted with a self-starter. The producer was two feet six inches in internal diameter and six feet three inches from grate to top. The air to the generator was induced by a jet of steam, not superheated. The gas on issuing from the producer passed through a scrubber of coke, nine feet high, through which a current of water was

*From the *Electrical Review* (London).

kept flowing, and through a sawdust purifier, to a gasholder of 740 cubic feet, and thence by a 5.1-inch pipe to the motor.

The temperature of the water was taken before entering the jacket, 66.2 degrees Fahrenheit, and after leaving the same, 108.5 degrees Fahrenheit. The exhaust temperature, 824 degrees Fahrenheit, was obtained by the calorimetric method. Indicator diagrams were taken by a Richards indicator. The brake used was of the rope type, now so frequently employed. The wheel was kept at a temperature of 79 degrees Fahrenheit, and was cooled by water internally, on the Druitt-Halpin system.

The indicated horse power was 110.4, the brake horsepower 74.82, therefore the efficiency of the mechanism was 69 per cent. The highest efficiency at the Society of Arts trials was 86 per cent., although for a much smaller engine.

It is the opinion of Prof. Witz that large size gas engines will replace steam engines of like power, much as small gas engines, at all events for town work, are at present used in preference to engines that require much personal attention. The whole matter, however, will resolve itself into one of convenience and cost, and the motor that will be most used will be that one which will give the minimum of trouble to the user, and whose cost shall not be prohibitive.

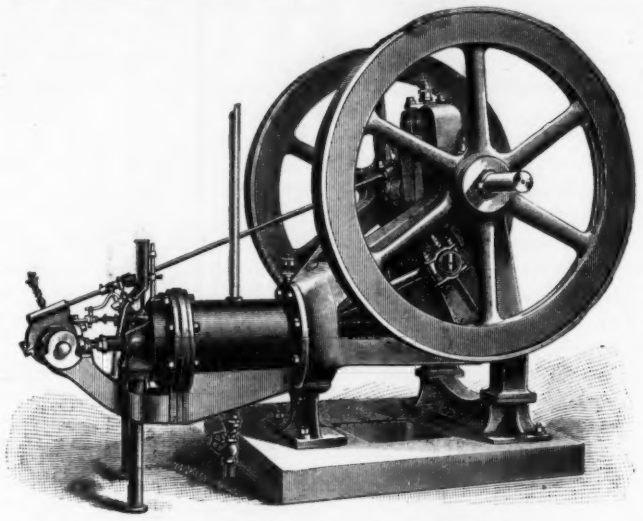


FIG. 1.—THE ATKINSON GAS ENGINE.

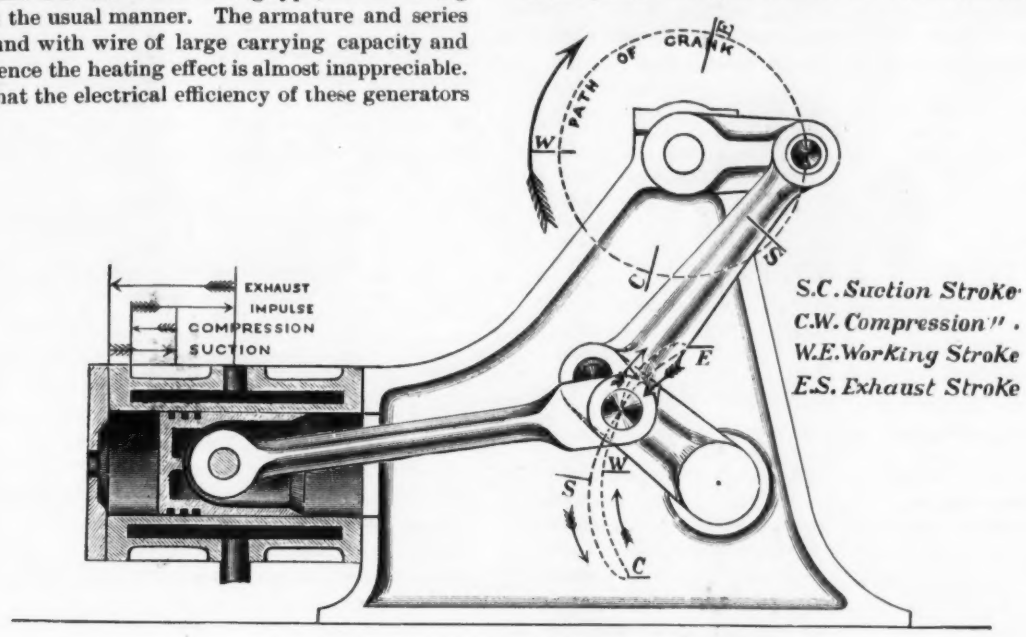


FIG. 2.—THE ATKINSON GAS ENGINE.

The Westinghouse Multipolar Generators.

The demand for large, slow-running generators for street railway work is constantly increasing as their advantages become more generally known and appreciated. To meet this demand the Westinghouse Electric and Manufacturing Company has placed upon the market a compound-wound, multipolar generator. This machine is at present built in three sizes, viz., 125, 250 and 500 h. p.

By referring to the accompanying illustrations it will be noticed that in general design these generators resemble the well-known Westinghouse alternating current dynamo. There is the same cylindrical yoke parting along a horizontal plane through the shaft, and the same arrangement of inwardly pointing pole pieces, but with a much smaller number of the latter.

The 125 and 250 h. p. machines have, as shown in Fig. 2, four pole pieces, and in the 500 h. p. size, see Fig. 1, there are six poles. In this latter machine the shaft has a bearing outside of the pulley, which relieves it in a large degree from the bending strain, and adds much to the rigidity of the armature.

The pole pieces are built up of thin sheet-iron plates bolted together and cast into the cylindrical yoke. The shunt and series coils are wound side by side upon metal bobbins, which are then slipped over the pole pieces, and held in place by bolts. The insulation of these coils as well as that of the armature is of ample thickness.

The bearings are self-oiling as well as self-aligning, and a great amount of bearing surface is obtained, owing to the length and large diameter of the journals.

The armature is of the Gramme ring type, the core being laminated in the usual manner. The armature and series coils are wound with wire of large carrying capacity and as a consequence the heating effect is almost inappreciable. It is stated that the electrical efficiency of these generators is from 94 to 96 per cent. at full load, a fact which indicates that the design of the machine is first-class.

These generators are wound for 500 volts, but they can be worked up to 550 or even 600 volts with the same armature speed, by throwing resistance out of the shunt circuit with the hand regulator.

In no respect is the excellent design of these generators more apparent than in the matter of regulation. The action of the series coils is such as to cause a considerable rise in voltage as the current being drawn from the machine increases. It is claimed that even at full load this rise in voltage is sufficient to make up for any ordinary loss or "drop" in the line.

The number of sets of brushes corresponds to the number of pole pieces, and the alternate ones, being of the same polarity, are connected together. Each individual brush has its own spring, by means of which its pressure on the commutator may be adjusted, and any one may be removed without disturbing the others. The dynamos are reversible, and may be run in either direction.

The railway switchboard of the company is equipped with Westinghouse appliances, some of which, namely, the circuit breaker and lightning arrester, were described in detail in the columns of THE ELECTRICAL WORLD of April 4 and 11, 1891. This board is arranged for three generators and three feeders.

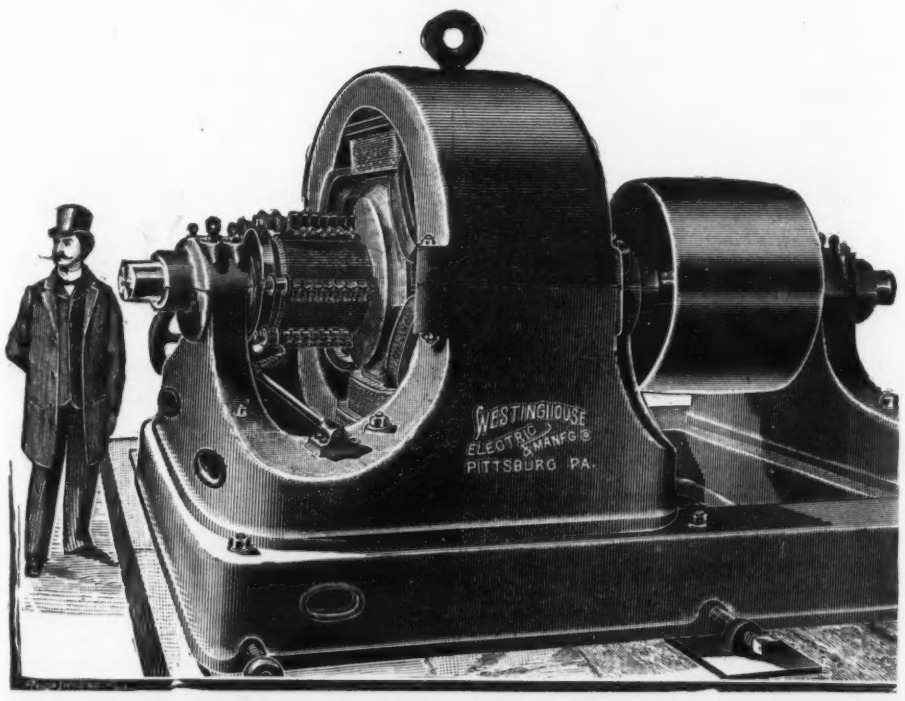


FIG. 1.—WESTINGHOUSE RAILWAY GENERATOR, 500 H. P.

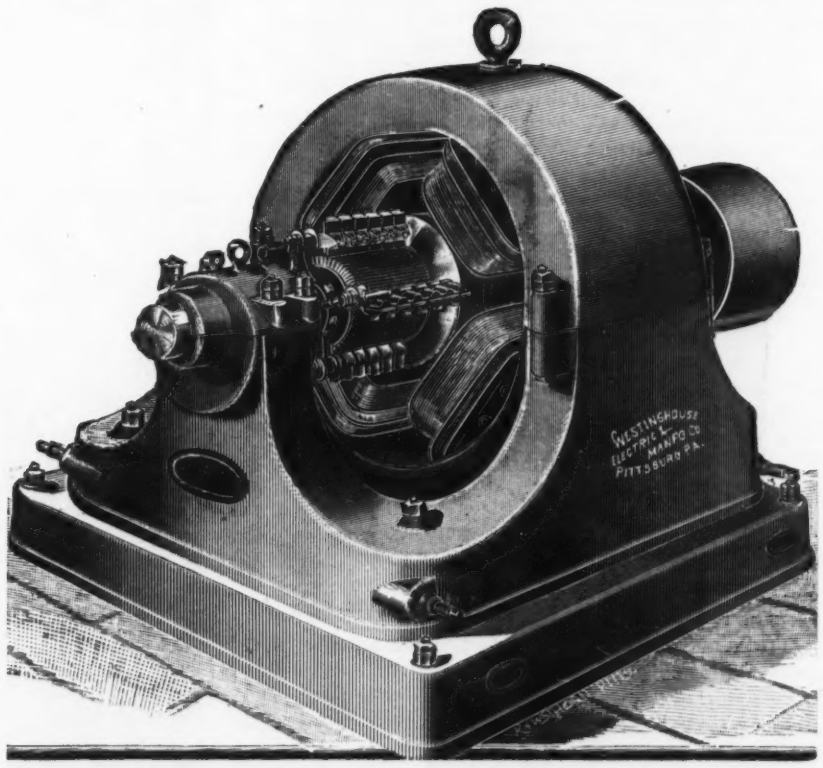


FIG. 2.—WESTINGHOUSE RAILWAY GENERATOR, 250 H. P.

The Atkinson Cycle Gas Engine.

As many small electric light plants are now operated by gas engines, any new machine of this kind that is placed upon the market must prove of interest to all who are connected with the installation of plants of this character. In describing this engine it is not our intention to give the history of the gas engine, but merely to call attention to the conditions necessary to obtain the greatest economy. Clerk, in his work, "The Gas Engine," refers to a pamphlet published by Beau de Rochas, in Paris, in 1852, and we quote: "He states that to obtain economy with an explosion engine, four conditions are requisite: 1. The greatest possible cylinder volume with the least possible cooling surface; 2, the greatest possible rapidity of expansion; 3, the greatest possible expansion; and 4, the greatest possible pressure at the commencement of the expansion.

In designing an engine to meet the conditions laid down above, the first may be provided for by careful designing, and the second by high piston speed, this being limited by the time necessary for complete combustion. But the difficulty begins with the third, as the greatest possible expansion can only be obtained by expanding the charge to a volume greater than the original volume; for when expanded to the original volume only, the charge will have a high terminal pressure, and if expansion is only carried to this point the products of combustion will be discharged with a large amount of energy not utilized. The difficulty also continues with the fourth, as the purer the mixture the higher will be the pressure at the commencement of the expansion, and in an engine in which the four strokes are of equal length it is impossible to obtain a pure mixture owing to the fact that the necessary compression space is, after the exhaust stroke, left full of the products of combustion, and these, of course, adulterate the charge and reduce the pressure. There is also another disadvantage attending the use of such a compression space, and that is, that it places a limit upon the size of the engine; for if an engine of large power is built the cooling surface of the cylinder will bear such a small ratio to the volume of the cylinder that the percentage of heat lost to the surfaces by the products of combustion during the exhaust, suction and compression strokes will be very small, and the temperature of the charge will be so high that when the heat due to compression is added a premature explosion will take place, and the motion of the engine be retarded or reversed. Consequently, to increase the power of engines after certain power has been reached, one or more cylinders have been added, forming, in reality, separate and distinct engines connected to one crank shaft.

A new engine has, however, appeared, which, it is claimed, not only overcomes the difficulties presented by

the third and fourth conditions, but also the latter trouble. The new engine referred to—Atkinson's cycle gas engine—performs all these operations in one revolution of the crank shaft. Fig. 1 is a perspective view of the engine, and Fig. 2 a sectional elevation showing only the mechanism by which the above operations are effected. It will be noticed that the different operations are obtained by the addition of but two parts—a link which vibrates through the arc of a circle, and a connecting rod, and by changing the position of the crank shaft in relation to the cylinder. The outer end of the piston connecting rod is attached to a pin passing through the crank connecting rod, and the

THE PAISTE SWITCH SOCKET.

latter is connected to the link; the different centres are so placed in relation to each other and to the centre line of the cylinder that the centre of the pin to which the piston connecting rod is attached travels in a curve resembling the figure eight, passing over the portion *S E* during the suction stroke, over *C W* during the compression stroke, over *W E* during the working stroke and over *E S* during the exhaust stroke. The figure shows that the compression stroke is shorter than the suction stroke, that the working stroke is almost double the suction stroke, that the exhaust stroke ends with the piston as close to the cylinder cover as it is possible mechanically to have it, and that the working stroke takes place in one-quarter of a revolution. It is apparent that with a given rotative speed great rapidity of expansion can be obtained with this engine, and that it is possible to expand the charge to such a volume that the terminal pressure will be reduced to the lowest practical point, and that, owing to the purity of the charge, the greatest possible pressure will be attained at the commencement of the expansion. Further, that, owing to the fact that practically all the products of combustion are expelled, the incoming charge will attain no higher temperature in a large engine than in a small one, and, consequently, large sizes can be built.

The results of tests made by disinterested parties are said to have shown that the friction cannot be any greater than in an ordinary engine. This engine has already proven successful in England and is now being manufactured in this country by reliable parties near Philadelphia.

A New Lamp Shade.

Aluminium has been put to many artistic uses lately, and every day we see additional proofs of its merits for decorative purposes. As pretty a thing as we have seen in this line is the new aluminium lamp shade manufac-

AN ALUMINIUM LAMP SHADE.

tured by the Electrical Supply Company, of Chicago, Ill. But lamp shades are useful as well as ornamental, and this new metallic shade has not only utility and beauty, but is many times more light in weight and more serviceable than those of glass.

The New Paiste Switch Socket.

Mr. Paiste, the well-known switch manufacturer of Philadelphia, has introduced a switch socket capable of carrying five ampères. Although the capacity of this socket is large the socket is not at all bulky, being, in fact, the same size as the usual socket. The workmanship is up to the well-known Paiste standard. Great care has been given to the manner of connecting the wires. By an ingenious device the wireman can use his discretion in choosing between a binding post and a binding screw. When in the act of wiring, both shells can be removed from the socket, leaving a clear, unobstructed chance to work. By means of a yoke and collar the socket can be securely fixed to a chandelier, and under no circumstances can the shell short circuit the wires. All insulating parts are made of Syracuse china, insuring a perfect insulation. Central station men will appreciate this socket, as there can be substituted large candle power lamps for the normal ones, without fear of destroying the working parts by overheating.

The Copenhagen Thermostat.

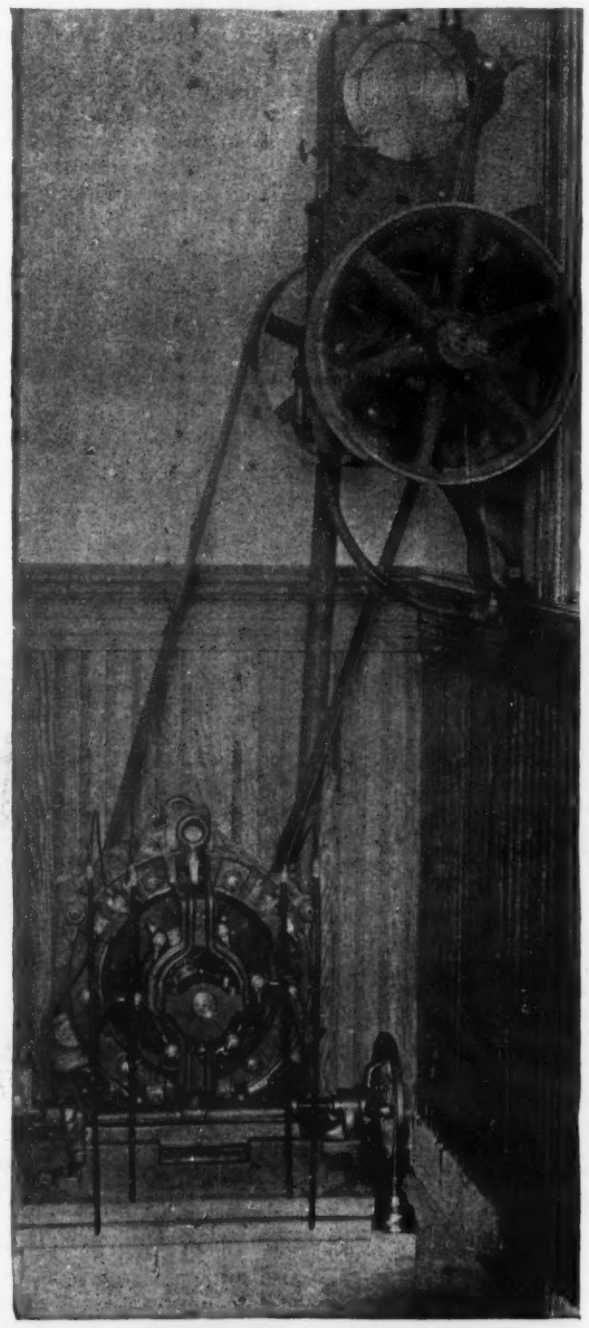
It is not often that there comes from foreign parts a device that partakes so much of the nature of a true Yankee notion as the one before us. The cut shows it in its actual size, ready for work. The base block supports two screw terminals. One of these communicates with a diminutive metallic capsule, held in place by three screws against its rim. This capsule has a very thin corrugated silver bottom and is filled with a volatile liquid. From the other terminal a wire leads to a contact point just beneath the capsule. When the temperature rises to the boiling point of the contained liquid the formation of vapor bulges out the bottom of the capsule and makes contact. On cooling the original state of things is restored. The apparatus thus

THE COPENHAGEN THERMOSTAT.

makes an excellent fire alarm, or gives warning of any rise of temperature above a point determined by the nature of the liquid employed. The Copenhagen Electric Alarm Company, of Cincinnati, introducer of this thermostat, is also making a similar form arranged so that the collapse of the flexible diaphragm which forms the bottom of the capsule withdraws a light spring pressure and allows a contact to be made. This latter arrangement serves as an alarm in cases where the temperature must be kept up to a fixed point.

A Compact Lighting Plant.

We illustrate on this page the rather unique lighting plant of the Staten Island Water Supply Company, at Port Richmond, Staten Island. The engine is an eight-horse



A COMPACT LIGHTING PLANT.

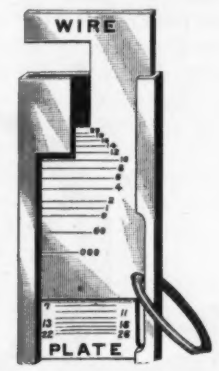
power J. T. Case high-speed bracket engine, running at 550 revolutions per minute. The dynamo is a 65-light Perret, running at a little higher speed than the engine. Both are located in a corner of the handsomely finished pump-house.

Floor space being a consideration, it could in no way be better economized than by using a high-speed bracket engine with a low-speed dynamo and belting vertically, as the pulley diameters are nearly the same and are large enough to prevent any possible slip.

The switchboard and molding throughout are of selected ash. In the pump-house 10 two-light polished brass bracket fixtures are placed at a height of 20 feet from the floor.

A Wire and Plate Gauge.

In the accompanying cut is shown a new wire and plate gauge which has been placed upon the market by Madison Rush, of 1004 Walnut street, Philadelphia. The cut shows the exact size of this useful little piece of apparatus, which, as will be seen, may be carried on an ordinary key ring without difficulty. It is simple in construction, and seems to be constructed in such a manner that it cannot easily get out of order. The gauge is so arranged that it shows the wire and plate numbers at the same time, and also,



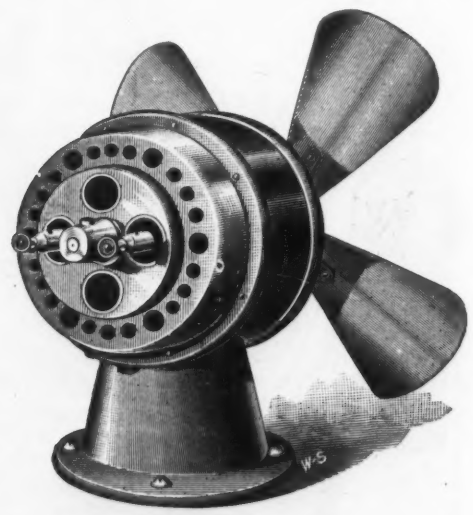
WIRE AND PLATE GAUGE.

on the reverse, not shown in the cut, the diameters in fractions of an inch. The instrument is made of polished steel.

Meeting of the Westinghouse Company.

The adjourned annual meeting of the stockholders of the Westinghouse Electric and Manufacturing Company was held June 1, and again adjourned until the 23d inst. Vice-President Bannister, who acted as chairman, stated that Mr. Westinghouse had been detained in the East, but he had a report from him regarding the progress of the plan of reorganization. The report stated that more than half of the stock had already assented to the plan, which had been very carefully considered by attorneys both in New York and Pittsburgh, and they have advised that all of its provisions, including the one for a seven per cent. annual preference upon the "assenting" stock, are legal and authorized by the company's charter.

Mr. Westinghouse also announced that the reorganization committee had concluded an arrangement for the purchase of the remaining outstanding shares of the United States Electric Lighting Company and the Consolidated Electric Light Company, and that the principal stockholders of those companies, who together hold more than half of the shares not now owned by the Westinghouse Company, have already entered into the arrangement, and it seems certain that the remainder will follow. Great advantages are predicted for the Westinghouse stockholders because of the simplification of its business, reduction of fixed charges and acquisition of additional property and facilities. One and a half million dollars' worth of stock, surrendered under the plan of reorganiza-



MESTON FAN MOTOR.

tion, will be reserved to carry out this purchase. There are now about 80,000 shares deposited with the Mercantile Trust Company of New York.

The Meston Alternating Fan Motor.

The electrician of the Emerson Electric Manufacturing Company, of St. Louis, Mo., has been engaged for some time in the work of designing an efficient type of alternating motor that could be applied to the operation of small fans, and the result is the little machine shown in the accompanying cut. The motor is of one-eighth h. p. and may be operated on any incandescent-light circuit. It is said that it takes 1.8 ampères on a 52-volt circuit. The construction is simple, there are no adjustments, and the working parts and coils are inclosed and protected from injury. The magnetic circuit is made up of very thin sheets of charcoal iron, and the bearings are self-oiling.

Report of the Rapid Transit Commissioners.

On Wednesday, May 27, the Commission at last gave to the public a preliminary report on the subject of its deliberations. Their lucubrations appeared in the following terms:

"*Resolved*, That after a thorough investigation it is the sense of this board that any additional rapid transit system for the city of New York should embrace the following essential features:

"1. That it should be such as to provide not only for present needs, but also be susceptible, by additions and not by radical changes or alterations, of such expansion as the future growth of the city may require.

"2. That it should provide for express trains at high speed for long distances, and for way service for intermediate distances, upon separate tracks, so located as to facilitate at proper intervals an exchange from express to local and from local to express trains.

"3. That the surface of the streets and avenues in the city should be obstructed to the least possible extent, and that whenever surface ground is required private instead of public property should be used if practicable.

"4. That the first lines of railway to be constructed should be on or near the important thoroughfare coincident—or as nearly so as possible—with the main arteries of travel.

"*Resolved*, That as meeting these requirements in the manner most feasible for the west side of the city, this board hereby approves of a plan for an undergronnd four-track railway under Broadway from a point at or near South Ferry to Fifty-ninth street; thence under the Boulevard to a point at or near 169th street, with such length of viaduct at and near Manhattan street as may be necessary; thence under Eleventh avenue, or under private property immediately to the west thereof, as may be found most convenient to such point as the contour of the ground may determine; thence by viaduct across Spuyten Duyvil Creek, and by tunnel or by viaduct to the city limits.

"*Resolved*, That the general plan of construction from, at or near South Ferry to near Forty-second street shall be either by double-decked tunnel, with two tracks upon each deck or four tracks on the same level, as may be found upon examination or survey most expedient; the hole to be at such depth below the curb line as not to disturb the surface or endanger building foundations; from near Forty-second street north to be four parallel tracks upon the same level; as near the surface of the street as practicable when in tunnel, but not in open cut at any point.

"*Resolved*, That the stations for such line of railway shall be open property acquired for the purpose, and shall be provided with ample elevator capacity wherever the platforms shall be 20 feet or more below the curb line.

"*Resolved*, That the motive power for such railway shall be electricity or some other power not requiring combustion within the tunnel.

"*Resolved*, That the engineers of the board be and are hereby instructed to make the necessary surveys and prepare in detail the plans and specifications for such railway, and submit the same promptly to this board for its further action in finally determining a general plan for submission to the Common Council in accordance with the provisions of the Rapid Transit act of Jan. 31, 1891."

It is understood that considerable modifications may be recommended at a later date.

The Sullivan Diamond Drill Operated by Electricity.

With the increasing employment of electricity in mining operations many of the standard types of mining machinery are being adapted for use in this manner by combination with electric motors. One of the most recent improvements of this kind is the diamond drill designed to be run by electricity. Such machines, manufactured by the Diamond Prospecting Company, of 15 and 17 North Clinton street, Chicago, Ill., have been in practical use for some time. The machine is simply a new arrangement of the well-known Sullivan drill. The motors used are adapted to any constant-potential electric current of sufficiently low voltage for safe use underground, and of sufficient strength to deliver 3 h. p. at the brushes. The device for feeding the drill-bit forward in this machine is a combination of the ordinary gear feed, with a friction clutch intervening, which not only avoids danger to the diamonds, but also results in most efficient and economical drilling.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

Westinghouse.—The report of this company's meeting held on June 1 will be found on the opposite page.

The Bell Telephone Company put out 408 more instruments for the month ended the 20th inst. than for the same period in 1890, but 1,120 more were returned, leaving a net decrease of 712. The statement of instruments for that period and since Dec. 20 is appended:

Month May 20.	1891.	1890.	Increase.
Shipments	7,346	6,938	408
Returned	3,255	2,132	1,120
Net output	4,091	4,803	*712
Since Dec. 20.	1890-91.	1889-90.	
Shipments	29,713	25,819	3,894
Returned	16,094	10,177	5,917
Net output	13,619	15,642	*2,023
Instruments in use May 20	495,249	459,383	35,866

*Decrease

European Welding.—The settlement which Mr. S. Endicott Peabody effected for the Thomson European Electric Welding Company in London was, according to the Boston *Herald*, as follows: The London purchasers agree to pay £5,000 of principal and interest on the unpaid balance up to June 1, and to pay £5,000 more on that date, unless the company was brought out then. If the condition of affairs in London did not favor bringing it out then, this payment was to carry an extension to Aug. 1, the unpaid balance to continue on interest. There has now been paid, including the first £5,000 above mentioned, £65,000 toward the purchase price of £100,000. The payment June 1 will make £70,000, leaving £30,000 still to be paid. Failure to pay the balance would constitute what has been paid a forfeit. The company has received a forfeit of £10,000 on account of the failure of the London parties to complete the purchase of the patents for the continent of Europe. It has received as well a considerable sum in interest on the unpaid contract of the English company, and it has rising $300,000 deposited with the American Loan and Trust Company, of Boston, drawing, it is believed, three per cent. interest. On the final payment by the English parties the money will be available for distribution. The European company made a mistake when it increased its capital stock. The act, which was quite unnecessary, caused delay which was fatal to the bringing out of the English company. Tight money came in London, and the "golden" opportunity was lost. But for this fact the sale might have long ago been completed and the money distributed, saving the English much expense, and the European company much expense and vexation. That the English people intend to complete the transaction is believed. They have purchased of welding people in Boston certain rights, etc., which did not belong to the European company, but which will be useful, and have made a large payment for the same. The new European company that is to use the Electric Welding Company's patents will be capitalized at £250,000 common stock and £10,000 founders' shares. The Boston people, in addition to the £100,000 cash agreed upon, and of which £65,000 is now paid, will get one-third of the common stock and £4,000 of the founders' shares.

Mexican Telephone.—The American *Wool Reporter* contains a very interesting article about the Mexican Telephone and Telegraph Company. It says: "The company has just received new concessions from the Mexican government for the Federal District of Mexico, to extend for twelve years, which give to the corporation a practical monopoly. During the past year the claim of the American Bell Telephone Company for $7,016.98 has been satisfactorily adjusted; bills payable in Mexico, amounting to $8,800, have been settled, and the entire remaining debt of the company has been liquidated, so that it will start on the new fiscal year with no incumbrances and several thousand dollars surplus on hand. There has been a handsome increase in the receipts over the previous year, and, contrary to what might have been expected, a decrease in operating expenses, which now are only 50 per cent. of the gross, while they formerly were larger sometimes than gross receipts. The first thing that the present manager found, when he took hold, was an acceptance of $5,000 and not a dollar on hand to meet it with. The company was badly in debt and had borrowed money at the rate of 24 per cent. a year to pay its most pressing claims. When the stock was selling as high as $6 and $7 per share, the company had no rights and franchises from the Mexican government that amounted to anything, and their patents had never been sustained in any court, and the company was in debt. To-day the company is free from debt, with a surplus, and its patents are valid, having been sustained by the highest court in Mexico, and they have just succeeded, as before stated, in securing valuable franchises. The company will begin to put in iron poles in some of the principal streets of Mexico, with aerial cables, with 100 wires in a cable. All told there will be 160 poles. Their wooden poles now used cost $47.50 each. Their iron poles will cost $25 each. It is estimated that by adding $500 per month more to operating expenses, the cost of this improvement will be liquidated. It will be completed by the end of the coming fiscal year. There will be no stock issued. In fact, there is no reason for apprehending any further issue of stock for several years."

The Closing Quotations of electric stocks, from F. Z. Maguire & Co., electrical securities, 18 Wall street, New York, on Friday, May 29, 1891, in New York, Boston and Washington were:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	80	80⅝
American Telegraph & Cable	100	14,000,000	83	85
Central and South American	100	5,000,000	135	145
Mexican	100	2,000,000	200	215
Commercial Cable Co	100	7,716,000	105	108
Postal Telegraph Cable	100	5,000,000	30	32
Edison General Electric Co	100	9,503,500	101½	102
" " Deferred	100	2,496,500	....	....
Consolidated Electric Light	100	1,929,400	....	....
Edison Electric Illuminating Co	100	2,567,800	76	78
United States Electric Light	100	1,500,000	30	31
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	43	44
" " preferred	25	4,000,000	25½	25¾
" " Series C	10	400,000	8¾	9
" " Series D	10	120,000	7	7¼
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1,000,000	....	....
" European Welding Co	100	1,000,000	60	70
Ft. Wayne Electric Co	25	4,000,000	12¼	12⅛
Westinghouse Electric Co	50	5,000,000	13⅝	13⅞
Detroit Electrical Works	..	.....	....	....
Telephone:				
American Bell	100	12,500,000	198	199
Erie	100	4,800,000	48	49
New England	100	10,304,600	50	....
Mexican	10	1,280,000	1.22½	1.25
Tropical American	10	400,000	....	60c.
Edison Phonograph Doll	10	1,000,000	50c.	....
WASHINGTON.				
Pennsylvania Telephone	50	750,000	25	....
Chesapeake & Potomac	100	2,650,000	61¾	63
American Graphophone	10	600,000	5¾	7
United States Electric Light (Washington)	100	300,000	158	165
Eckington and Soldiers' Home Electric Ry	50	352,000	49½	51
Georgetown and Tennallytown	50	200,000	57	61

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$230@$240	Cumberland	$60@ $62
Central Union	56@ 57	Wisconsin	118@ 120
Michigan	86@ 88	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$104@$105	Chicago Edison Co	$145@$150

NEW INCORPORATIONS.

The National Electric Valve Company, with a capital stock of $100,000, has been incorporated at Cincinnati, O.

The Rhodes Electric Company, of Los Angeles, Cal., has been incorporated. The capital stock is $10,000. Directors: S. H. Rhodes, S. A. Kendall, W. W. Dodd, A. M. Edelman, and L. T. Rhodes.

The Riverside Electric Light and Power Company, Chicago, has been incorporated with a capital stock of $250,000, to furnish power, water, heat and light. Incorporators, Frederick S. Moffett, H. P. Caldwell, George C. Short.

The Anglo-American Gas Control Company was incorporated last week for the manufacture of gas and electricity for illuminating purposes. The company's capital stock is $200,000. The directors are: L. A. Kelley, G. T. Gaden, S. F. Long, H. S. Tatum, J. J. Bowen, H. A. Williams, and J. P. Langhorne.

The Rocky Mountain Electric Light and Supply Company has been organized, with a capital stock of $50,000, to carry on a general electrical supply business. The office of the company will be in Butte City, Mont. The incorporators are: Harry C. Kessler, John O'Rourke, William Owsley, M. L. Holland, Frank Shaw, James A. Tupper and S. W. Graves. Mr. Graves is secretary of the company, and Mr. James A. Tupper was formerly manager of the Butte Electric Light Co.

AFFAIRS OF THE COMPANIES.

The New Albany Electric Light Company has failed. Liabilities and assets are about $50,000 each.

The Oakland and Berkeley Rapid Transit Company is contemplating bonding the property for $500,000, and it is authentically stated that capitalists are ready to take it at that figure, being confident that it will pay the interest.

The Electric Protective Company, of Philadelphia, elected the following officers and directors at its annual meeting recently: President, Charles M. Swain. Directors, Charles M. Swain, R. Lloyd Lee, R. L. Brownfield, John R. McFetridge and W. P. Wheatland.

The Philadelphia (Pa.) Local Telegraph Company held its annual meeting last week. The following officers and directors were elected: President, Henry Bentley; secretary and treasurer, William P. Wheatland. Directors, Henry Bentley, James Merrihew, Charles A. Tinker, John Van Horne, W. B. Gill and W. P. Wheatland.

The South Jersey Telephone Company.—The company which controls all the telephonic service in the southern part of New Jersey, including Camden and Atlantic City, held its annual meeting this morning and elected the following officers: President, James Merrihew; vice-president, William B. Gill; secretary, Charles A. Jenke; treasurer, W. J. McLaughlin.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, June 1, 1891.

The following well-known electrical people were registered at the A. B. C. Company within a few days: Geo. W. Adams, Boston; Herbert A. Wagner, St. Louis; Gilbert Donaldson, St. Paul; Sam'l L. Stein, Pawtucket, R. I.; J. B. Moore, Minneapolis.

The McLean Engineering Company, a firm of consulting and contracting engineers, has opened offices at Room 601, Electrical Exchange Building, 136 Liberty street, New York, and will give special attention to the erection of steam and electric plants and the installation of Edison electric motors.

Mr. W. J. McPherson, electrician, has just completed a novel electrical apparatus for Alfred De Cardova, the well-known banker, at his stock farm near North Branch, N. J. Mr. Cardova's farm is situated some miles from the railroad, and when he is away from his New York office a basket of carrier pigeons is sent to the station in the morning and transferred by messenger to his banking offices. During the day he is notified of any important changes in the stock market by means of his pigeons, which when they alight at his farm fly into a box arranged so that immediately their weight presses a lever, which releases electrically the door, which drops into place, and thus imprisons them and at the same time rings a bell in Mr. Cardova's house announcing the arrival.

The Franklin Experimental Club held its regular meeting recently, at which Prof. C. Sonn delivered an interesting lecture on "Seismology," or the "Phenomena of Earthquake Disturbances," and methods of studying the same. Prof. Sonn dwelt upon the various theories prevalent upon the subject of earthquakes, tidal waves, etc., and explained the methods adopted from the earliest times to the present day in the study and recording of the various disturbances going on in various parts of the earth's structure. The lecture was illustrated by magic lantern views of the most important earthquakes and their effects in Japan, Sandwich Islands, Lisbon, Charleston and elsewhere, and also by diagrams, prepared by the Professor, of the electrical and other methods employed in recording the time and duration of the disturbances, and number and general character of the movements. Some interesting pictures were shown of various buildings and the effects of the shocks upon structures placed in certain positions, and he explained that as nearly all of the impulses moved in one direction, it was customary in earthquake countries to pass stringent laws stating how buildings were to be set, whether the windows and doors, etc., would be allowed in walls which ran in certain directions, relative to the seismic movements, the character and materials employed. The president exhibited some interesting samples of lava and earthquake souvenirs collected by him at Herculaneum, Pompeii, and the Island of Isckia. Prof. Sonn sails for Europe shortly, and during his visit abroad will visit the Electrical Exhibition at Frankfort and will prepare an interesting report for the Franklin Experimental Club.

L. H. H.

NEW ENGLAND NOTES.

BOSTON, Mass., May 30, 1891.

The Detroit Electrical Company has opened an office in the Exchange Building, Boston.

The Shaefer Electric Company is about to move its factory from Cambridge to more commodious quarters at Marlboro, Mass.

The Thomson-Houston Company has been putting a sand blast machine in its shops at Lynn for frosting incandescent lamp globes.

The Consolidated Electric Manufacturing Company has received and shipped during the past week some large orders

for supplies for Finland and Denmark. Among the items was one for 2,000 lamp sockets.

The Eastern Electric Supply and Construction Company is meeting with great success with its new "Eastern Electric" door pull.

The Whitney Electric Company has been incorporated at Saco, Me., for the manufacture of electrical apparatus. The incorporators are Boston, Lowell and Saco parties.

The Redding Electric Company is nicely settled in its new quarters, 41 Federal street, and has some very attractive offices and salesrooms. The factory is still on Hanover street, and is connected by telephone with the office.

The Cohassett (Mass.) Electric Company has completed arrangements for the enlargement of its plant. The additions will include a new 750-light dynamo, an exciter, about 300 planed hard pine poles and about 20 miles of wire.

The Automatic Time Stamp and Register Company is in receipt of orders for its machines from all parts of the country. One of its new employès' registers was put in the mailing department of the Boston post-office last week.

The Lynn & Boston Electric Railway has been granted the privilege of extending its line from Atlantic station to the Point of Pines. This virtually gives a line the whole length of the beach, and it is expected that it will be completed in time for the rush of visitors to that resort this coming season.

The Evans Friction Cone Company is receiving many orders for its well-known cones, among which are the central station at Cedar Rapids, Ia.; Warren (Pa.) Electric Light Company (second order); National Transit Company (fourth order); one for Edison General Electric Company for United States lighthouse steamer America, and one for the Watervliet arsenal, West Troy.

The Augusta, Hallowell and Gardiner Electric Railroad Company at its recent annual meeting decided to build a new power station in Hallowell, Me., north of the car houses. It is to be of brick, 80 × 45 feet. Two 150 h. p. boilers will be installed, leaving room for four more when necessary, and a 250 h. p. Corliss engine has been contracted for. At present only two generators will be set up, but the station is so arranged that two more engines and four more generators can be added when the line is extended. The water power at Gardiner will still be used, being much cheaper, but the above addition is large enough to run the entire road. The coal sheds which join the station are so arranged that coal can be supplied readily from the railroad. C. A. B.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, May 30, 1891.

Mr. R. F. Piatt, of Monticello, Ill., is in Chicago, arranging for the installation of an electric light plant.

The Thwing Electric Company's effects will not be sold until June 8, and there is a fair prospect of the business being continued in Chicago.

The Hill Clutch Works, Cleveland, O., has secured the contract for furnishing the transmitting machinery to the Frostburg (Md.) Electric Light Company.

The Electric Engineering Company, Monon Building, Chicago, is conduiting and wiring the Fourteenth street pumping station for both arc and incandescent lights.

Messrs. J. W. Calkins & Sons, The Rookery, Chicago, have sold two 500 incandescent light dynamos to the National Electric Construction Company for its local station.

Mr. H. H. Pattee, of Monmouth, Ill., was in Chicago last week looking after the interests of his lamp hour recorder, which has since its introduction met with considerable success.

Mr. George B. Shaw, the general manager of the National Electric Company, Eau Claire, Wis., manages to pay a hurried visit in Chicago about twice a week when en route East or West.

The Underground Question.—Capt. G. N. Stone and Mr. John Kilgour, of Cincinnati, are in Chicago, looking up the subject of underground conduits in connection with telephone and street railway service.

Mr. C. G. Armstrong, the Auditorium, Chicago, is preparing plans and specifications and calling for bids for supplying the material and machinery for installing central electric light stations at Monticello and Wheaton, Ill.

Storage Battery Cars.—The Dubuque, Ia., daily papers devote two columns to the excellent service rendered by the storage-battery cars on the local streetcar line, the cells used being of the Accumulator type, and furnished by Mr. William Hood, of Chicago.

The Charles Munson Belting Company, of Chicago, shipped a handsome 72-inch double-leather belt 152 feet long to the Missouri Railway Company, of St. Louis, this week, and though weighing 1,980 pounds, it is comparatively light.

Mr. Henry Hine, manager of the Stanley Electric Manufacturing Company, Pittsfield, Mass., is one of the welcome visitors in Chicago this week. Mr. Hine has been visiting Detroit and Cleveland, and will return to New York with some handsome orders in his pockets.

Mr. George S. Searing, the Chicago manager of the National Electrical Manufacturing Company, of New York, has removed to room 341 The Rookery. Mr. Searing has secured some handsome orders of late, outside of the regular trade which he has built up since his arrival in the West.

The Purdue University, of La Layette, Ind., has issued its catalogue for 1891-1892. The book shows this university to be a most completely equipped college for an electrical engineering course, and upon the staff list and in the faculty are to be seen some of the best names in the country.

Mr. George H. Meeker is now nicely settled in new headquarters at 78, 80 and 82 Franklin street, Chicago, Ill., and is daily booking orders for Grimshaw white core wires. Mr. Gallaher is visiting Mr. Meeker this week, and will probably call on some of their Western agencies before returning to New York.

The Rose Polytechnic Institute, of Terre Haute, Ind., has sent us one of its ninth annual catalogues. The Rose Institute has a well-arranged plan of study, and the engineering course is very thorough indeed, some of our best electrical engineers being graduates of the college. The shops in the Rose Institute are under the management of a long experienced corps of expert mechanicians, and the equipment is a most complete one.

Mr. Raymond Gregg, general inspector of time service on the Burlington railway system, Chicago, is replacing the gravity and open-circuit cells in use on the time-service circuits with secondary cells manufactured by The Accumulator Company, Philadelphia. The secondary cells are giving excellent satisfaction under constant work, and are found to be cleaner, more easily handled and more economical than many of the cells heretofore used.

A New Agency.—The Electrical Supply Company, of Chicago, has secured the general western agency for the goods made by the Stanley Electric Manufacturing Company, of Pittsfield, Mass. The peculiar features and novel construction of the Stanley transformers, and the Stanley alternating current fan motors, have attracted favorable attention and comment. The Electrical Supply Company will carry a full line of these specialties, and has now in press a comprehensive illustrated catalogue descriptive of the apparatus.

The Thomson-Houston Electric Company has recently sold through its Western isolated department the following apparatus: Smith Steam Baking Company, of Kansas City, Mo., one 50 incandescent light plant equipment; Wainwright Real Estate Company, of St. Louis, Mo., one 3,000 incandescent light plant equipment; Iowa Agricultural College, of Ames, Ia., one 6 arc light dynamo, one 35 incandescent light dynamo, one 1 h. p. motor and miscellaneous appurtenances for laboratory use; Cudahy Packing Company, of Chicago, Ill., one 125 incandescent light dynamo; Carson, Pirie, Scott & Co., of Chicago, Ill., one 35 arc light and one 400 incandescent light dynamo; S. S. Badger, of Ouray, Col., one 100 incandescent light plant equipment; Central Market Company, of Chicago, Ill., one 18 arc light dynamo and 200 incandescent light dynamo; Chicago City Railway Company, one 150 incandescent light dynamo, and H. H. Shufeldt & Co., of Chicago, Ill., one 250 incandescent light dynamo to increase the capacity of the plant sold last November.

The Columbian Exposition.—Arrangements are being perfected whereby engines, dynamos, generators will be suitably displayed in the annex building, each exhibitor erecting a small model station on plans approved by the electrical engineer of the construction department, Mr. Sargent. The rest of the exhibitors will be placed in the Electricity building, and the two buildings probably connected by a subway six feet in diameter, along the walls of which the various conductors will be supported on suitable hooks. This will enable manufacturers of dynamos to meet competition by exhibiting their apparatus under conditions best suited for their purpose, and to do so profitably, as each will probably secure a fair slice of the contracts awarded for lighting the grounds and buildings or be allowed to furnish current to the company securing the contract for furnishing power, etc. The question of location of exhibits rests entirely with the chief of the department and the exhibitor. If a manufacturer of electric mining apparatus desires his exhibit to be placed among the electrical apparatus, and Chief Barrett is willing to receive it there is where it will probably be placed. Electric lights are to be placed in the grounds at once, in order to aid the workman if they desire to work at night, and to assist the fire department should a fire occur. A circular will shortly be issued, giving detailed information regarding the work done thus far and outlining the steps to be taken by exhibitors.

The Sperry Electric Mining Machine Company is nicely settled in the new quarters corner of Stewart avenue and Thirty-ninth street, Chicago, where it occupies a large share of the extensive works owned by the Link Belt Machinery Company, the president of which is also the president of the Sperry Mining Company. As the buildings occupied have just been constructed, they are finished in modern design, and include every convenience required in the manufacture and handling of heavy machinery. Thus the Sperry Mining Company enjoys facilities that are seldom obtained by new companies without the investment of several hundreds of thousands of dollars. For instance, within the grounds there is located the pattern shop and foundry with cranes and hand cars for moving heavy castings from the foundry to the planers in the machine shop, and then to the other departments, till finally the great cranes lift the finished machines into the freight cars that are run alongside of the buildings. Thus equipped for the heaviest and best class of work, the company is rapidly turning out the few parts required in the mining machine, and, after assembling, sending the machines to the coal mines located in every section of the country. On the improved form of mining machine the body or main part consists of but a single iron casting, including the bearings for journal and armature shaft, while the few bolts and other small parts used are of the same relative size and interchangeable. Another important improvement in the new form of machine is the arrangement of the buffer so that the main casting bears the entire strain should the runner fail to strike the mineral. This improved mining machine has shown its efficient qualities in a remarkable degree by breaking coal for 18 hours constant work in the Ohio mines. This company is also building mining locomotives and a form of motor for pumping-duty in mines, while the building of large generators to order is a special feature of the work. F. de L.

Cincinnati, May 30, 1891.

The Cincinnati Electrical Supply Company has just been incorporated with a capital stock of $100,000.

Covington, Ky., has banished its last street-car mule, and the Main and Scott street line has adopted electricity.

Prof. Nelson Perry, the well-known electrical engineer, is seeking a position with the Bureau of Promotion and Publicity of the World's Fair.

The Committee on Light of the Board of Legislation of the city have considered the matter of lighting Cincinnati with electricity, and an ordinance for that purpose is about as good as passed. There will be no monopoly. The present price of $144 per lamp charge by the Cincinnati Gaslight and Coke Company will probably be greatly lowered. It is claimed lamps can be furnished at about $80 per year, as is done in smaller towns. The Edison people count upon being a successful bidder against the Gas Company. There will be a bitter fight, however, before the contract is awarded.

The Edison General Electric Company is rapidly pushing the work of laying conduits in the heart of the city, in accordance with the permission granted it by the Board of Administration. The company has already conduits three-quarters of a mile from its station on Plum and Eighth streets, and has reached some of the most valuable points of the city. It already takes in the Pennsylvania depot, the Central Union Railway station, the magnificent new city buildings and several large manufactories. The company has contracts made to turn on lights by Oct. 1, and by December it will have its million dollar building completed.

St. Louis, Mo., May 30, 1891.

Mr. Morgan Jones, 705 North Main street, St. Louis, will shortly place an electric brake on the market.

Mr. A. J. Hatch, formerly of Cleveland, O., and now secretary of the Fidelity Carbon Manufacturing Company, of St. Louis, has become quite an admirer of the business activity and enterprise shown by the St. Louis merchants, especially in the matter of raising large sums for the usual fall festivities.

Mr. J. A. J. Shultz, of the Shultz Belting Company, St. Louis, Mo., in referring to the 154 feet of 72-inch belting that he has just furnished to the St. Louis & Suburban Street Railway Company, and which, by the way, is one of the largest railway belts ever turned out, remarked that the growth of his company was coincident with that of the electrical industry, and that fifteen years ago the trade of his company was confined to the mills within a limited territory desiring the best quality of belting, while now he is furnishing belts to all lines of industry, but more especially to electric lighting and railway companies.

ENGLISH NOTES.

(From our own correspondent.)

London, May 20, 1891.

Overhead Wires.—An enterprising little company at Sheffield which holds the unique position of being at one and the same time an electric lighting and telephone company, has recently had its overhead wires most adversely reported on by Major Cardew, the Board of Trade adviser, who considers the insulation dangerously insufficient and utterly untrustworthy. He says, moreover, that he cannot view the maintenance of the present system in such a crowded town as Sheffield without grave apprehension. The result of this report has been that the municipal authorities have immediately written to the company to ask what they propose doing, and have passed a resolution to the effect that all electric light wires should go underground.

Gas and Electricity in Westminster Palace.—The subject of lighting Westminster Hall and the Houses of Parliament has received considerable attention at the hands of Members of Parliament this session, who once having been able to appreciate the benefit of the electric light are anxious that it should be extended throughout the huge building. With a view no doubt of accelerating this improvement attention was called recently to the fact that some damage had been done to the hammer beams in Westminster Hall by the gas lamps placed some 15 or 20 feet below them. Although the officials in charge thought that no permanent injury had been done to this magnificent woodwork, they were glad to say that gas was being replaced by electricity throughout the palace as rapidly as possible.

Sims-Edison Torpedo.—Questions are being asked about this torpedo in the House of Commons with a view of eliciting whether the Admiralty is keeping its eye on its performances and capabilities as compared with a similar torpedo recently purchased by the English government for an enormous sum from its inventor, Mr. Brennaw. As far as one can judge from reports of trials of the two torpedoes respectively, it would seem as if the Sims-Edison machine were more easily manageable, had a longer range, and had a more rapid rate of travel than the Brennaw. English naval officers have, it was stated in the House of Commons last week, watched the trials of the Sims-Edison torpedo and will report thereon to the Admiralty.

"Giraud" Thermopile.—The thermopile and the voltaic battery seem destined to share between them the attention of visionary enthusiasts. Within the last few weeks Mr. Hospitalier has been giving great prominence in a French engineering newspaper to a thermo-electric stove devised by a Dr. Giraud, of Chantilly. Mr. Hospitalier points out that while the thermopile is hopelessly out of the running when we regard the electricity it generates as its primary product, it has some possibilities of usefulness if we regard the electricity generated as a secondary product; in other words, if we can have at one and the same time a good stove and a good thermopile. Some such device has been evolved by this Dr. Giraud, who has built a stove of the usual cylindrical French form and grouped around the central flue several hundred thermo-electric elements (nickel or "feo-blanc" and zinc-antimony). A small stove, consuming the usual quantity of fuel, is said to be able to produce about one kilowatt-hour per day, which, if stored in accumulators, would enable one to run some twenty-five 100 c. p. lamps.

Electric Traction on the West Metropolitan Tramway Company's System.—The West Metropolitan Tramway Company, which adopted some few months ago the Lineff closed conduit system of electric traction for its line from Hammersmith to Kew, has been successful in getting its bill for this purpose passed through the House of Commons. The only opponent of the measure was the National Telephone Company, which, supported by the evidence of Sir William Thomson and Sir Frederick Bramwell, succeeded in getting the insertion of a clause compelling the Tramway Company to insulate its wires in such a way as not to interfere with the working of the telephone. As was to be expected in this country, the electric traction companies being the last comers are likely to have to defer to the tender susceptibilities of the telephone, though so far no hard and fast rule with regard to "earth" has been laid down, but the traction companies have merely been made responsible for any disturbance they may cause to the telephone. If they can use "earth" and *not* disturb the telephone so much the better for them.

News of the Week.

THE TELEGRAPH.

New York City.—The Fire Commissioners last week appropriated $775 for placing cables in the subway, and connecting the various hospitals with the Fire Department.

New Southern Lines.—The Postal Telegraph Cable Company has secured right of way from Richmond along the county road to Newport News, Hampton and Old Point, Va. Another wire also goes from Richmond to West Point.

Meeting of the New York Telegraph Club.—About 250 telegraph operators and their friends attended the annual summer night's festival of the New York Telegraph Club, held last week at the Empire Coliseum, Sixty-seventh street and East River. The club has over 400 members, all of whom are operators in New York and adjoining cities. Its rooms are at 32 Cortlandt street, where entertainments are given regularly every month during the summer.

THE TELEPHONE.

Telegraph Line Across the Boundary.—The Canadian-Pacific telegraph line is now completed to the boundary at Sumas, Wash., and one wire is in operation from Seattle through to the Canadian Pacific main line. Mr. Jed G. Blake, manager of the Postal lines in Seattle, Wash., is to meet James Wilson, superintendent of the Pacific division of the Canadian Pacific telegraph line to complete arrangements for working the lines in connection. The Postal has three wires on this line and two on the old highway line.

San Francisco, Cal.—The Pacific Telephone and Telegraph Company reported last week that it has expended $53,369.76 in laying conduits for the use of telephone and telegraph wires under ground. The franchise granted to this company required it to ex-

pend $50,000 in the work during the first year to preserve the franchise. The telephone company is getting its wires under ground in view of the expiration of the Bell patents. No other company will find it easy to compete, as franchises for overhead wires will probably not be granted.

THE ELECTRIC LIGHT.

Noblesville, Ind., will soon be lighted by electricity.

Atlantic, Ia., has just finished installing its electric light plant.

Fond du Lac, Wis., is to erect an electric light plant. Water power will most likely be used.

Dallas, Tex., has closed an eleven-year contract with the local electric light company for street and arc lights.

The Badger (Wis.) Illuminating Company contemplates an addition to its plant which will cost about $25.000.

Exeter, N. H.—It is expected that work on the Exeter Electric Light and Power Company's plant will begin about June 15.

Harrisburg, Pa.—The City Council has decided to place electric lights all over this city, and work will be begun at once.

Boise City, Idaho, is to close a contract with the Capital Electric Light Company to light the city with 2,000 c. p. arc lights.

Elyria, O.—The electric light station was put in successful operation last week. The plant starts with 65 municipal arc lights.

St. Paul, Minn.—Mr. A. L. Sackett is advertising for bids for an isolated light plant for the Minnesota Hospital for the Insane.

Mount Pleasant, Ia.—The Mount Pleasant Road Scraper Company is to furnish the city of Mount Pleasant with electric lights.

Ahnapee, Wis.—Messrs. A. Hamacet & Co. have finished work upon their electric light plant and the city is now most efficiently illuminated.

Cambridge, Mass.—Harvard University is to be lighted throughout by electric light. The Edison company is now at work upon the installation.

Youngstown, O., is to reduce the price charged for electric lights on commercial circuits, as the success of the lighting enterprise has long warranted such a step.

The Mt. Pleasant Electric Light and Power Company, of Mt. Pleasant, Westmoreland County, Pa., has been granted a charter and will erect an electric light plant during the present summer.

Waukesha, Wis.—The Silurian Mineral Spring Company has let a contract for the installation of an electric light plant, which is to be completed toward the end of June. The plant will have a capacity of 12 arc and 50 incandescent lights.

St. Louis, Mo.—Mr. C. A. Daigh, of the Electrical Engineering and Supply Company of St. Paul, Chicago and Duluth, has just closed a contract with the Consumers' Electric Lighting and Power Company for furnishing the entire station equipment.

Brunswick, Me.—The Maine Electrical Improvement Company has secured the contract for the construction of the Brunswick Electric Light and Power Company's plant. The station is situated upon an island in the Androscoggin River and is supplied with abundant water power.

Bellevue, O.—The Howe Construction Company, of Norwalk, O., is installing an electric light plant for street and commercial lighting. For the street lighting is to be used: One 30 2,000-c. p. arc dynamo of the Western Electric Company, and one 160 32-c. p. Heisler incandescent dynamo. For the commercial lighting is to be used one 460 32-c. p. Heisler incandescent dynamo.

Mr. Arthur Hartwell, of the Westinghouse Company's electrical engineering force, has just returned to Pittsburgh, after an absence of several months on the Pacific Coast. Mr. Hartwell had charge of the installation of the Westinghouse system for the Willamette Electric Light and Power Company, of Portland. The power for the Willamette plant is furnished by means of water situated 12 miles from the city.

THE ELECTRIC RAILWAY.

Dubuque, Ia.—The new storage battery road is now in operation, and since the first run last week everything has given perfect satisfaction.

To Use Gearless Motors.—The Westinghouse company has secured the contract to equip the street railway at Williamsport, Pa., with the company's new gearless motor. This will require about 30 motors and is to be completed in two or three months.

GENERAL APPLICATIONS OF POWER.

Large Hoisting Plant.—At the Black Diamond mines, in Washington State, an electric hoisting machine has been placed at the top of a slope 450 feet in length, for the purpose of hoisting coal, the top of the slope being 3,100 feet from the mouth of the mine The generator which supplies electricity to the motor attached to the hoist has a capacity of 120 h. p., and is located at the mouth of the mine, while the motor is capable of exerting 80 h.p. when needed. Yesterday on a test 12,000 pounds of coal were hoisted at one trip up the slope in one and one-half minutes. The plant was manufactured and installed by the Electrical Engineering Company, of San Francisco, under the supervision of Professor Keith, the inventor, and is pronounced a thorough success. It is claimed that it makes practicable the working of many coal and other mines which could not be so cheaply and effectively worked by the usual methods of steam or pneumatic transmission of power.

LEGAL NOTES.

Edison vs. United States Company.—The trial of the suit of the Edison Electric Light Company against the United States Electric Lighting Company to settle the ownership of the incandescent lamp was begun before Justice Wallace in the United States Circuit Court last week.

The Pleasant Valley Line, of Pittsburgh and Allegheny, has just added to the rapid-transit facilities of the sister cities by the opening of its Troy Hill branch. This new branch reaches the summit of Troy Hill, a populous suburb of Allegheny, and will doubtless prove a profitable venture for the projectors.

The Western Union Must Show the Telegrams.—As requested by the Federal grand jury at Los Angeles, Cal., Judge Ross has issued an order directing Frank Jaynes, superintendent of the Western Union Telegraph Co., to produce all the telegrams in his possession which have passed over the wires relating to the schooner "Robert and Minnie" and the Chilian steamship "Itata" between April 1st and April 15th.

Pfannkuche vs. The Brush Company.—The Brush Electric Company were made defendants last week in a damage suit for $150,000. Gustav Pfannkuche is the plaintiff and alleges that he entered the company's employ under a special contract and transferred to them certain patents which they now refuse to surrender after having broken the contract. The patents are said to be very valuable, and Mr. Pfannkuche does not propose to surrender his right to them.

No Damages for Feelings Injured.—The Supreme Court rendered a decision last week in the case of the Western Union Telegraph Company vs. W. H. Rogers. Rogers recovered in the lower court a judgment for $800 damages for wounded feelings caused by the delay in delivery of a message announcing the death of his brother The Supreme Court reversed this judgment, and held that such damages were not recoverable, except in cases of bodily injury, of malice, oppression, or willful wrong.

Thomson-Houston Company vs. The Hughes & Gawthrop Company.—The Thomson-Houston Electric Light Company, of Philadelphia, and the Thomson-Houston Electric Company, of Boston, Mass., have filed a bill in equity against the Hughes & Gawthrop Company, the local representatives at Pittsburgh of the Thomson-Houston interests. The defendant company, it is stated, was organized with a capital stock of $25,000. Its assets amount to $48,000, and its liabilities foot up about $79,000. The plaintiffs are creditors to the amount of $39,000, of which the Philadelphia company holds $24,000 and the Boston one $15,000. The defendant company, it is alleged, is unable to pay the indebtedness and intends to confess judgment to Paul H. Hacke, the president of the company, or some one in his interest, for $21,000. A meeting of the stockholders was called a few days ago for this purpose. The bill states the intention is to give Hacke preference over other creditors, which would be an injustice. An injunction is asked for to restrain the Hughes & Gawthrop Company from selling or assigning its property or confessing any judgment, and to have a receiver appointed to take charge of the affairs.

PERSONALS.

Mr. David J. Hobart, general manager of the Mexican Company, last week died suddenly at the City of Mexico.

Mr. Henry Lewis, of New York City, has been appointed division superintendent of the Pennsylvania Telephone Company, with headquarters at Philadelphia, to fill the vacancy occasioned by the recent promotion of W. J. Bampfield as general manager of the company. Mr. Lewis will assume charge at once.

Industrial and Trade Notes.

The Electrical Supply Company, 171 Randolph street, Chicago, reports that owing to the steady demand for its "Shield" brand weather and moisture proof wire, the company has been forced to increase the capacity of its plant at Ansonia, Conn.

The Fidelity Carbon Manufacturing Company, of St. Louis, Mo., has again secured the contracts for several car loads of battery carbons for Eastern battery manufacturers, which is a fair indication of the high quality of battery carbon manufactured by this company.

The Electric Wiper Company, Market street, St. Louis, Mo., is finding ready sale for its raw silk machine wiper among careful engineers, electricians and users of small motors, who appreciate the value of a wiper that leaves no lint behind, and does its work thoroughly and completely.

Mr. George Cutter, of Chicago, has recently filled some very large orders from various parts of the West for rubber tape and tubing, and has found the "black elastic" rubber tape especially in demand. This is made from pure gum, and when properly applied to wire joints makes them thoroughly waterproof.

Mr. James H. Mason, of 120 Park avenue, Brooklyn, has accepted the Eastern agency of the Hay-Horn Mfg. Co. for all of that company's specialties, including the Walter Hay bell, which was recently described in the columns of THE ELECTRICAL WORLD, and which has met with a remarkable commercial success.

Lamp Trimmers' Carts.—The central stations in Salt Lake, Utah; Denison, Tex., Trenton, N.J., and St. Louis, Mo., are equipped with the Cooney arc lamp trimmers' cart as a measure of economy. Wherever trimming is necessary on arc-light circuits of any length the amount of time saved in using a Cooney cart will be found to be sufficient to offset its cost within a short period.

The Columbia Incandescent Lamp Company, 1,912 Olive street, St. Louis, has recently added a new incandescent dynamo of the National (Eau Claire) type and 36 new pumps, thus largely increasing its output. This increase has been necessary for some time owing to the demand that has steadily grown since the Columbia lamp was first placed on the market.

Messrs. Himmer & Anderson are meeting with great success with their dry battery, orders for some 500 cells having been received during the last few days. They are also receiving orders from Canada and South America. At a recent test one of their cells worked continuously nine days on a two-ohm resistance bell. At their new location, on Chambers street, they will have a capacity of 2,000 cells per week.

The Nassau Smelting and Refining Works, of 540 to 544 West Sixteenth street, New York City, manufacturer of solder, tube, babbitting, brass and spelter metals, has been doing a very large business in the electrical sphere. This company is the successor of the well-known firm of B. Lowenstein & Brother, formerly of 4 and 6 Desbrosses street. This company is the manufacturer of the "Edison" babbitt metal.

The Jerome Kidder Manufacturing Company, of 820 Broadway, New York City has received the following testimonial from Dr. W. M. Powell, of Albany, Tex., concerning the medical battery manufactured by that company: "Your machine is still the 'chief.'" Drs. Williams and Williams, of Oak Cliff, Tex., also testify as follows: "We have been using your Faradic battery since 1884, and are now using it almost daily in our practice; deprived of our batteries we would signally fail to cure many cases we otherwise restore to good health."

The New Process Raw Hide Company, of Syracuse, N. Y., referring to the statement made in Mr. G. A. Jungren's article in THE ELECTRICAL WORLD of May 23, that raw hide gears "are not very durable," says: "While this is undoubtedly true of raw hide in general, it does not apply to new process raw hide; our gears outwearing both bronze and steel, as is certified to by such authorities as the Morgan Engineering Company, of Alliance, O.; J. H. Vandeveer, general manager of the Scranton, Pa., street railways, and Mr. William M. Ramsey, in charge of the electrical department of the Federal Street & Pleasant Valley Railway Company, of Allegheny, Pa.

The American Electric Elevator Company, of New York City, has recently put in operation an electric elevator in the Grimes Building, at Kansas City, which runs at a speed of 250 feet per minute and carries an average load of 1,200 pounds with an expenditure of about nine horse power, The installation, it is said, gives excellent satisfaction. The elevator car runs very smoothly and quietly, much more so than the average hydraulic elevator. This company is now installing a number of elevators in various parts of the country, among which may be mentioned the one for the Duquesne Traction Company's car house at Pittsburgh, Pa., for the purpose of raising the cars, a load of about 10,000 pounds, from the track on the first floor to the paint shop on the floor above. This plant will soon be in operation.

The Ball Engine Company, of Erie, Pa., has received among other letters of a similar nature, the following communication from Messrs. D. B. Baker & Whitmarsh, of Abington, Mass.: "We bought the 20-27 h. p. Ball engine which we are now using to run our factory and isolated electric light plant about two years ago. It was not an absolutely new machine when we bought it, but it has not cost us a cent for repairs, and we cannot say too much in praise of it on the score of economy and fine regulation, There are many things about the running of a shoe factory which will go wrong in spite of all that can be done, and when we get particularly discouraged we go out and look at the way our little Ball engine is working, and it invariably encourages us, as it demonstrates the fact that there is at least one part of our mechanism that is always doing its work satisfactorily without making any fuss about it."

The Sperry Electric Mining Machine Company, of Thirty-ninth street and Stewart avenue, Chicago, Ill., has issued its circular, giving a price-list of fuse wire, ranging from 1 to 200 ampères. The company says in the circular: "Our experience in adapting electrical machinery to mining and railroad work and in furnishing supplies for arc and incandescent lighting plants has shown that there was a pressing need for a more accurate system of fuse wire than has yet been offered to the public. As fuse wire is directly in the line of electrical supplies and specialties we have decided to add it to our list, and have prepared, at large expense, from a series of careful tests a full and complete line, which may be relied on for correctness of carrying capacity and absolute uniformity of sizes and alloy. This wire is calculated for all classes of work, being just the thing in the small sizes for ceiling rosettes and fuse boxes, while the heavier grades will insure against burn outs in mining and railroad service.

Carhart-Clark Standard Cells.—Considerable attention has recently been given by electricians to the subject of standard battery cells, as such an instrument is indispensable for use in calibrating voltmeters and in all cases when an absolute standard E. M. F. is necessary. The regular Clark cell did not prove satisfactory, as it cannot be carried about and must be set up in the place where used. To overcome this serious defect Prof. H. S. Carhart, of the University of Michigan, devoted a large amount of time to the subject, and about two years ago brought out the Carhart-Clark standard cell, which has been extensively used with most excellent results. By a special process Prof. Carhart makes these cells so that they can be carried in the pocket or sent from place to place without any deterioration, so that they are perfectly portable. Another remarkable feature of this cell is its very low temperature coefficient, which has been reduced to .00033, this making, for all practical purposes the temperature change inappreciable. Every cell is accompanied by Prof. Carhart's certificate. These cells are placed on the market exclusively by Messrs. Queen & Co., of Philadelphia, Pa.

The Ball Engine Company, of Erie, Pa., has received the following letter from Mr. C. G. Lyman, secretary of the Queen City Electric Light Company, Cincinnati, O.: "We have one 100 h. p. and two 150 h. p. Ball engines; all three of them are run under exceedingly trying circumstances for any engine. The smallest one has been in use now nearly two years, one of the larger ones about 18 months and the other one a year, and when we consider the circumstances that two of these engines have to run alongside of the boilers in the fire-room, being exposed to the dust and ashes from the same, it is remarkable that we have not had a great deal of trouble with them; but we are pleased to say that they have always done their duty in a highly satisfactory manner, and we look upon the Ball as one of the best high-speed engines." The following letter was received from the Naugatuck Electric Light Company, of Naugatuck, Conn.: "Your favor of the 21st inst. received, and beg leave to say that we have used one of your 60 h. p. engines for over four years with entire satisfaction, and are so pleased with its operations that we are now erecting a 200 h. p. cross compound engine of your manufacture."

The Hall Railway Signal Company, of 50 Broadway, is achieving deserved success in the introduction of its electric signals. Any one who has had to do with railroad officials understands that it is next to impossible to introduce on their lines anything new. Only a distinctly meritorious device will be examined, and then it often requires years of labor to make the venture profitable. Knowing these facts, but feeling that it had the best signal in the world, the Hall Company several months since made a proposition to the New York Central & Hudson River Railroad Company to equip about 10 miles of double track between Oscawana and Roa-Hook, one of the most dangerous positions of the road. It was accepted, and 27 line block signals, 10 miniature signals, and nine bells at switches and highway crossings were installed. These signals have worked so perfectly that they have been accepted by the Central, and it is fair to presume that they will not stop there, but render life and limb more safe by equipping all the dangerous portions of the road with this most essential apparatus. Other roads have not been slow to recognize the signal's merit, and are also rendering main tracks safer by its use, among the notable ones being the New York, New Haven & Hartford, the Michigan Central, the Central Railroad of New Jersey, and the Chicago, Milwaukee & St. Paul.

Business Notice.

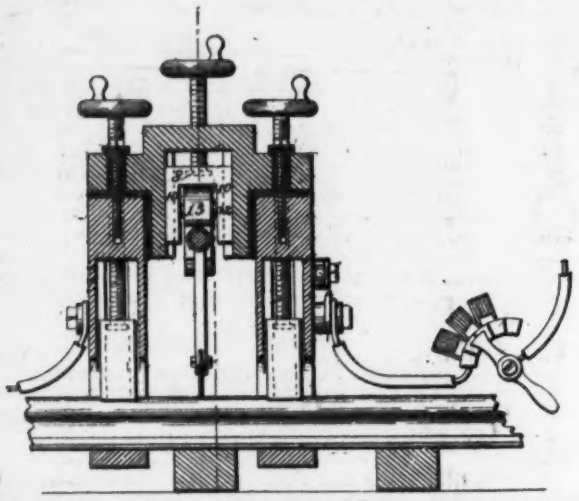
Intelligent people, who are familiar with the respective advantages which are offered by the several competing railroad lines between Chicago, St. Louis and Kansas City, and who desire to travel with the utmost speed, safety and comfort, always take the popular and reliable Chicago & Alton Railroad between these points, and passengers going to or coming from the South, via St. Louis, or when going to or coming from the West, via Kansas City, should insist upon having tickets that read over the Chicago & Alton. It is the only road with three complete and elegantly equipped trains daily between Chicago and each of the points named, and no railroad managers in America have a more intelligent appreciation of the wants of the traveling public than do those of the famous Chicago & Alton.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENT ISSUED MAY 26, 1891.

452,771. Police Signaling Apparatus; Henry A. Chase, of Boston, Mass. Application filed July 18, 1890. In an electric signaling apparatus, a signal-transmitter, comprising a motor mechanism, a signaling key, and a removable signal wheel fixed to a tubular shank, and a head on said shank, on which the number on the wheel is placed.

52,775. Telephone Receiver; Charles T. Dickson, of Cincinnati, O. Application filed Aug. 14, 1890. The combination in a telephone receiver of an ear piece adjacent to the diaphragm of the receiver, an air space between the diaphragm of the receiver and the ear piece, an aperture communicating with the air space and transmitting sound to one ear, a tube depending freely from



No. 453,164.—ART OF REPAIRING METAL STRUCTURES BY THE AID OF ELECTRICITY.

the ear piece, communicating with the air space, and having at its free end a second ear piece whereby sound is transmitted to the other ear, the tube being so arranged that the sound waves caused by the vibration of the diaphragm will be admitted to it before passing out of the aperture.

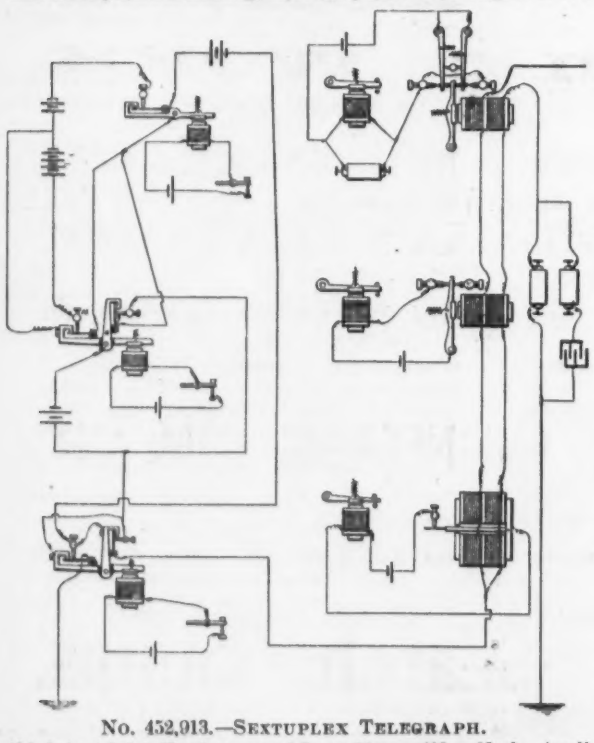
452,780. Incandescent Electric Lamp; Isaac J. Flagg, of Clinton, Mass. Application filed Sept. 17, 1890. An incandescent lamp having its bulb and socket in one piece of vitreous material and the insulated suspensory containing the conducting wires combined with terminals for the lamp and with which the said conducting wires are joined within the socket, and water and moisture proof insulation surrounding the said terminals and the bared conducting wires at their point of junction within the said socket.

452,785. Coin-Controlled Annunciating-Machine; Harry M. Hamrick, of Philadelphia, Pa. Application filed Feb. 24, 1891. A coin-controlled machine having a slot for the reception of coins of different denominations, a series of spring-actuated contact switches connected together by a conductor leading to one electrode of a battery, a series of contacts connected together by a conductor leading to the other electrode of the battery, a movable plate, lugs for separating the coins and detaining those of like denominations above certain of said switches and beneath said movable plate, and means for shifting said plate in order to cause said coins to turn said switches into engagement with said contacts.

452,795. Electric Motor; Charles J. Kintner, of New York. Application filed June 14, 1890. An electric motor having a field magnet core divided at its neutral point, in combination with an armature carried by a shaft having longitudinal movement in its journal bearings, and a fan attached to one end of the armature-shaft.

452,796. Hollow Braided Lightning-Rod; George R. Kress, of Pittsburgh, Pa. Application filed Nov. 8, 1890. The invention consists of a lightning rod or conductor formed as a hollow braided continuous conductor, which may be, when finished, either tubular or rectangular.

452,871. Automatic Safety Electric System for Locomotives; Edwin Deming, of Brooklyn, N. Y., Assignor of two-



No. 452,913.—SEXTUPLEX TELEGRAPH.

thirds to Adolph Kaufmann and Isaac Stern, of New York. Application filed Sept. 18, 1890. In a locomotive, the combination with the throttle valve of a stationary piece provided with teeth, a handle provided with a movable catch, having teeth engaging with said former named teeth, a lever crank carried by said handle and connected to said catch, an electric motor, and a rod provided with a hole through which pass said lever crank and said handle, said rod being connected to a crank upon the shaft of said motor.

452,872. Automatic Safety Electric System for Railways; Edward Deming, of Brooklyn, N. Y., Assignor of two-thirds to Adolph Kaufmann and Isaac Stern, of New York. Application filed Sept. 20, 1890. (See 452,871 above.)

452,873. Automatic Electric Safety System for Railway Switches and Drawbridges; Edward Deming, of Brooklyn, Assignor of two-thirds to Adolph Kaufmann and Isaac Stern, of New York. Application filed Sept. 22, 1890. (See 452,871 above.)

452,874. Automatic Electric Safety System for Railway Crossings; Edward Deming, of Brooklyn, N. Y., Assignor of two-thirds to Adolph Kaufmann and Isaac Stern, of New York. Application filed Sept. 24, 1890. (See 452,871 above.)

452,875. Multiple Fuse-Block; Lorenzo R. Favor, of Gloucester, Mass., Assignor to the Thermal Electric Company, of same place. Application filed Nov. 3, 1890. A thermal cut-out having a spring-actuated finger and a conductor bar insulated from each other and electrically connected with the respective ends of the line-wire, pivoted contact-dogs insulated from each other, the tension-wires connecting said dogs with said bar, and fusible plugs of paraffine, spermaceti, or the like, interposed as a resistance to the tension of said wires.

452,913. Sextuple Telegraph; Thos. A. Edison, of Menlo Park, N. J., Assignor to the Western Union Telegraph Company, of N. Y. Application filed June 2, 1877. In a sextuple telegraph, the combination with transmitting keys operating to send the proper currents of three receiving instruments, the first of which responds to reversals in the polarity of the current, the second responds to either of the two currents that are above a medium strength, and the third responds to a current of the greatest strength, or to no current from the transmitting batteries. (See illustration.)

452,920. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa., Assignor to the Electric Car Company of America, of same place. Application filed April 28, 1886. The combination of two or more electric motors, a vehicle conveyed and propelled thereby, power-transmitting devices between the two motors and each of the axles of the vehicle, reversible commutator brushes for each motor, means controlled at will by the operator for actuating said brushes to change the direction of rotation of the motor, a resistance in the motor circuit and means for automatically controlling said resistance.

452,921. Electrical Switchboard; John B. Lyon, of Brooklyn, N. Y. Application filed Jan. 19, 1891. A section of weight-guide tubes for electrical switchboards, consisting of a plurality or group of rubber tubes, each provided inside with electrical contacts or electrodes, which are provided with lugs extending outside the group, and all the tubes secured together by vulcanizing the rubber. (See illustration.)

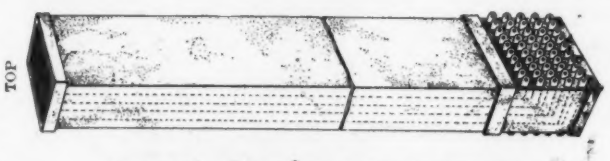
452,931. Electro-Mechanical Gong; Frederick W. Cole, of Newton, Mass., Assignor of one-half to Moses G. Crane, of same place. Application filed Dec. 9, 1890. An electro-mechanical gong having a striking arm or lever and controlling mechanism therefor, and releasing mechanism for said controlling mechanism governed by the armature of an electromagnet, a component part of said releasing mechanism serving as a retractor for the armature.

452,932. Electro-Mechanical Gong; Frederick W. Cole, of Newton, Mass., Assignor of one-half to Moses G. Crane, of same place. Application filed Dec. 9, 1890. (See 452,931 above.)

452,934. Electric Motor or Generator; Walter K. Freeman, of Brooklyn, N. Y., Assignor to William S. Hadaway, Jr., trustee, of Boston, Mass. Application filed Jan. 13, 1891. In a motor-frame, the combination of end castings, each formed in one piece and having sides provided with a connecting portion, around which the field-coils are wound, and flanges at each end of said connecting-piece on the outside.

452,935. Electric Motor or Generator; Walter K. Freeman, of Brooklyn, N. Y., Assignor to William S. Hadaway, Jr., trustee, of Boston, Mass. Application filed Jan. 13, 1891. A frame for electric motors consisting of two sections, each formed in one piece and having a concave portion, arms extending on opposite sides of the same, and a half core piece at the bottom.

452,936. Electric Meter; Walter K. Freeman, of Brooklyn, N. Y., Assignor to William S. Hadaway, Jr., trustee, of Boston, Mass. Application filed Jan 13, 1891. In an electric meter, the combination of a motor and its armature, a form bearing the characteristic curve of the motor, developed by observing the performance of said motor under variations of current, and which



No. 452,921.—ELECTRICAL SWITCHBOARD.

form receives motion from the armature of the motor, with recording mechanism, and mechanism for transferring the motion of the form to said recording mechanism. (See illustration.)

452,937. Electric Switch; Walter K. Freeman, of Brooklyn, N. Y., Assignor to Wm. S. Hadaway, Jr., trustee, of Boston, Mass. An electric switch having a series of contact pieces, a segment in proximity thereto, swinging arms adapted to make contact with said segment and series of contact pieces, respectively, and an inclined stud or pin upon which said arms are mounted.

452,951. Armature for Dynamo-Electric Machines or Motors; Elihu Thomson, of Lynn, Mass., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed March 5, 1890. A ring-armature core having a removable plug, with projections at its inner portion interlocking with the core ends to prevent spreading of the core and outward displacement of the plug, the remainder of the plug and core ends tightly fitting one another, but having no interlocking parts preventing inward movement of the plug.

452,955. Electric Transmitting Clock; Henry S. Prentiss, of Elizabeth, N. J. Application filed June 6, 1890. In combination with a transmitter, its escapement wheel and a pallet lever, a primary clock provided with a cam or eccentric, a rod connecting the pallet lever of the transmitter with the eccentric of the primary clock, and means for adjustment between the rod and the pallet lever.

452,956. Synchronizer for Electric Clocks; Henry S. Prentiss, of Elizabeth, N. J. Application filed June 6, 1890. In an electric clock system, a switch actuated at determined intervals to break the connection at the main line and close it through a synchronizing line, in combination with a series of switches, one for each clock, for throwing such clocks into or out of the synchronizing line.

452,983. Grounding Device for Lightning Rods; Cassius M. Radford, of East Concord, N. H. Application filed Jan. 19, 1891. In a grounding device for lightning rods, a straight rod for connecting with a lightning rod and a rod forming a helix surrounding said straight rod and attached thereto, in combination with a metal tube having at its lower end a detachable conical plug for driving into the ground, and suitable filling for said tube.

452,992. Electric Motor for Wheeled Vehicle; Robert S. Dobbie, of Jersey City, N. J. Application filed May 9, 1890. A wheeled vehicle having an electric motor elastically supported, and having its rotary part secured to a hollow sleeve which surrounds an axle of the vehicle and is provided with elastic or yielding bearings at its opposite ends between it and the axle. (See illustration.)

453,000. Electric Connection for Distributing Telephone Lines; Wm. M. Goodridge, of Highland Park, Assignor to the Western Electric Company, of Chicago, Ill. Application filed Feb. 7, 1889. A switchboard having a strip placed at the rear thereof and provided with spring terminals, said spring terminals being connected at the rear with the wires of the return portion of the cable, the front ends of said spring connectors being connected with the keyboard apparatus.

453,029. Multiple Cut-Out for Electric Distribution Systems. Application filed Feb. 15, 1891. The invention consists in such construction, whereby several cut-outs may be connected on one side with a common bus-bar, by means of U-spring switches arranged so as to permit of the ready disconnection of any cut-out from the bus-bar. In this manner each circuit of lamps would be provided with a cut-out at each point of attachment to the main feeders.

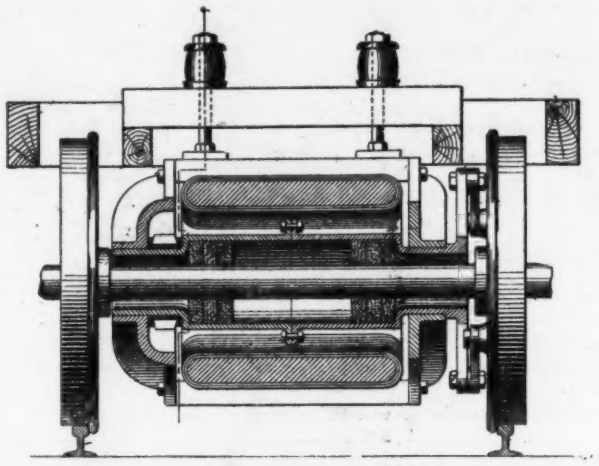
453,031. Electric Motor; Elbridge Baker, of Malden, Mass. Application filed July 5, 1890. An electric motor having its armature inclosed within the driving-wheel, and its field magnet suspended beneath the same.

453,032. Automatic Electric Switch Mechanism; Harry H. Blades, of Detroit, Mich. Application filed Sept. 19, 1890. An automatic switch mechanism for an electric motor, the same consisting of a switch governing the admission of current to the motor, an electromagnet on an independent shunt circuit, an automatic switch lever on the armature circuit, a series of resistances with their terminals arranged to successively engage the said switch lever, and a dash pot to retard the motion of the lever, said lever actuated by the armature of the said electromagnet.

453,036. Adjustable Support for Electric Wires; Thos. H. Brady, of New Britain, Conn. Application filed Feb 13, 1891. A bracket for supporting wires, consisting of a socket-piece having a base to facilitate fastening in place, a socket extending in a direction parallel to said base, and a second socket extending substantially at right angles to said base, and a bracket arm having a pin at its outer end for holding an insulator, a shank to fit said socket at its opposite end, and an angular body between said pin and shank.

453,041. Electric Display Burner for Oil Lamps; Wm. A. Drysdale, of Philadelphia, Pa. Application filed Feb. 16, 1891. An electric display burner for oil lamps, the same comprising the electric lamp, its socket, and an outer casing inclosing and hiding said socket, the whole being constructed for application to the reservoir of an oil lamp.

453,046. Electrical Safety Switch; Geo. L. Hall, of Lowell, Mass. Application filed March 19, 1890. In a closed electric circuit, a movable double switch consisting of two movable switches, one arranged in the line out and the other in the line in, said switches being insulated from each other but mechanically connected to each other, an electro-magnet arranged in the same circuit, and its armature secured to one of said switches, said magnet being arranged to hold said switches closed when the



No. 452,992.—ELECTRIC MOTOR FOR WHEELED VEHICLE.

current is uninterrupted and at other times to allow said switches to be opened and the circuit to be broken in two places.

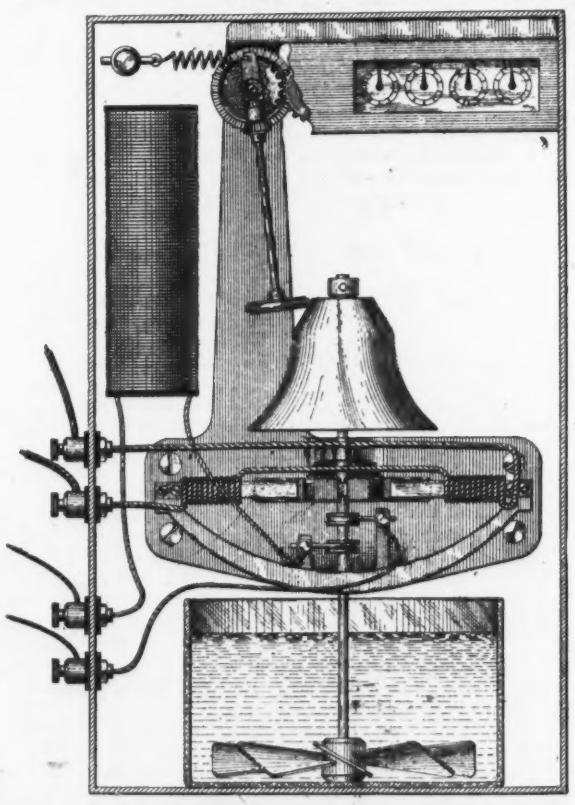
453,070. Support for Trolley Wires; Geo. K. Wheeler, of Chicago, Ill. Application filed Nov. 21, 1890. The invention consists of a metallic basket or trough adapted to receive the trolley wire, and also adapted to admit the passage of the trolley-wheel, and provided with ears which can be bent over the trolley wire after it is placed in the trough, in order to hold the wire in proper contact with the trough, and also provided with means for connecting it to the usual insulator between it and the span wire.

453,093. Trolley-Wheel; John Sullivan, of Washington, D. C. Application filed Feb. 19, 1891. A trolley-wheel for an overhead electrical conductor, having toothed portions in the bottom of its peripheral groove.

453,097. Electric Railway-Signal; Willie Cowles Walter, of Richmond, Va.; Sophia Lee Walter, executrix for said Willie Cowles Walter, deceased. Application filed Nov. 11, 1889. An electric signaling system comprising a conductor extending parallel with the track and insulated from the ground, and located beside and normally out of engagement with a rail and electrically connected with said conductor.

453,100. Insulating-Clamp for Span-Wires; William E. Baker and Charles H. Macloskie, of Boston, Mass. Application filed Jan. 9, 1891. The combination, with a pole-ring clamp, of a yoke or link jointed at one end to the clamp and having at the opposite end a socket, an insulating plug extending through the socket supported therein, and having a central or fice, and an eyebolt adapted to engage a span-wire and having its shank adjustable in the orifice of the insulating plug.

453,104. Electric Contact Brush; Jas. R. Branch, of Richmond, Va. Application filed Oct. 28, 1890. A contact brush consisting of a bracket, a supporting-rod carried by said bracket in vertical adjustment, the hollow holder rigid on the lower end of



No. 452,936.—ELECTRIC METER.

said rod, and the carrier removably located in said holder and carrying the contact devices.

453,111. Electric Fuse Box; William Edson, of Boston, Mass., Assignor to the Beacon Vacuum Pump and Electrical Company, of Maine. Application filed Jan. 21, 1891. The invention consists of a fuse box so constructed that it may contain a number of fuses, and that in case a fuse is burned out a part rotation of the movable section of the box will place another fuse in the circuit.

453,164. Art of Repairing Metal Structures by the Aid of Electricity; Elias E. Ries, of Baltimore, Md. Application filed Nov. 9 1889. The method of repairing fixed metal structures, which consists in cutting out the defective or objectionable section, and then inserting a new section in place of the old and welding it at both ends electrically to the fixed structure. (See illustration.)

453,167. Electric Locomotive or Street Car Motor; Rudolf Eickemeyer, of Yonkers, Assignor to the Eickemeyer-Field Company, of New York. Application filed Oct. 28, 1890. In an electric street car or locomotive the driving-wheels and axle, a slow speed electric motor having an iron cored amature, field coils which surround and directly polarize the armature, and a shell or casing which surrounds the armature and coil, springs which relieve the motor from strains and shocks imparted from the rails to the axles or driving-wheels, and pitmen or links with cranks which directly connect the armature shaft and the driving-wheels or axle.